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DET NORSKE VIDENSKAPS-AKADEMI I OSLO

# HVALRÅDETS SKRIFTER

## SCIENTIFIC RESULTS OF MARINE BIOLOGICAL RESEARCH

EDITED BY
UNIVERSITETETS INSTITUTT FOR MARIN BIOLOGI AND
STATENS INSTITUTT FOR HVALFORSKNING

**Nr. 51**

ROBERT CLARKE
NATIONAL INSTITUTE OF OCEANOGRAPHY,
UNITED KINGDOM

ANELIO AGUAYO L.
ESTACION DE BIOLOGIA MARINA
DE MONTEMAR
DE LA UNIVERSIDAD DE CHILE, CHILE

OBLA PALIZA
INSTITUTO DEL MAR DEL PERU, PERU

# SPERM WHALES OF THE SOUTHEAST PACIFIC

PART I: INTRODUCTION

PART II: SIZE RANGE, EXTERNAL CHARACTERS AND TEETH

WITH 13 FIGURES

OSLO
UNIVERSITETSFORLAGET
1968

Dale, with our best wishes.

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# Part I. Introduction

## General

Since the whaleships first sailed into the Southeast Pacific Ocean at the end of the eighteenth century, one of the most important of the world's sperm whaling grounds has been the region which extends through equatorial latitudes from beyond the Galápagos Islands almost to the coast of Ecuador, and thence southwards along the coasts of Perú and Chile, and seawards of these up to some two hundred miles, as far as the latitude of about 45°S. This is an upwelling region where the very high organic production in the Humboldt Current (Fig. 1) includes an immense squid population which undoubtedly accounts for the abundance of sperm whales (*Physeter catodon* Linnaeus).

At the present time no whaling is conducted from the coast of Ecuador nor from the Galápagos Islands, but recent catch figures for Chile and Perú, compiled from the *International Whaling Statistics*, are sufficient to show the contribution of the Southeast Pacific ground (Table 1). During the ten years 1956—1965 the two countries have between them accounted for nearly 45,000 sperm whales, or about one fifth of the world catch of this species. Whalebone whales, comprising humpback, blue, fin and sei whales (Clarke, 1962a) and Bryde's whales (Clarke & Aguayo, 1965), and the protected southern right whales (Clarke, 1965), are all to be found in the region, but for technical and economic reasons the whaling companies of Perú confined their catch to sperm whales until 1964, whilst in Chile whalebone whales were only a small fraction of the catch until 1965. The interest in whalebone whales since 1964 is not necessarily to be regarded as an indication of a decline in the sperm whale stocks, but we cannot here pursue the matter further, having mentioned whalebone whales only to put into perspective the predominant importance of sperm whales in the Southeast Pacific.

Pelagic factories have worked in these seas before and after the Second World War, but the catches shown in Table 1 were all made from shore stations. Fig. 1 shows the six shore stations whaling into the Humboldt Current during the period 1959 to 1961 when the material analysed in the present series of papers was collected. In Chile these are the stations of Macaya Hermanos y Cía at Caleta Chome at the south end of the Tumbes Peninsula near Talcahuano (36°40'S, 73°10'W), and of Cía Industrial at

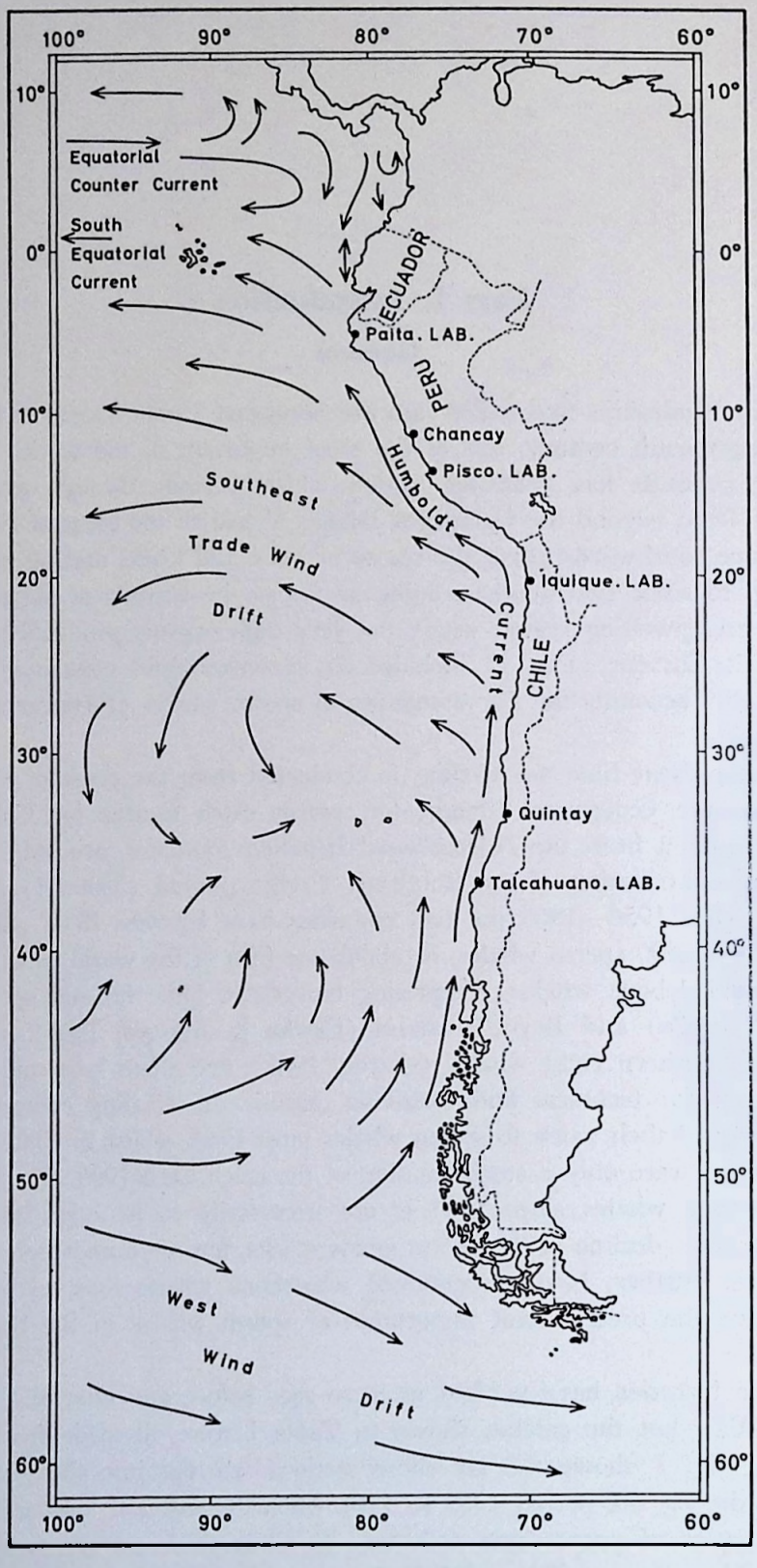


Fig. 1. Whaling stations operating on the west coast of South America between 1958 and 1961. Surface currents of the Southeast Pacific (mainly after Schott, 1943) are also shown.

Table 1. *Annual catches of sperm whales and whalebone whales for the World and for Chile and Perú from 1956 to 1965.*

| Year | Sperm Whales | | | | | | |
|---|---|---|---|---|---|---|---|
| | World | Chile | | Perú | | Chile and Perú | |
| | | Nos | % | Nos | % | Nos | % |
| 1956 | 18590 | 1171 | *6.30* | 2019 | *10.86* | 3190 | *17.16* |
| 1957 | 19156 | 2299 | *12.00* | 2381 | *12.43* | 4680 | *24.43* |
| 1958 | 21846 | 2062 | *9.44* | 2554 | *11.69* | 4616 | *21.13* |
| 1959 | 21298 | 2062 | *9.68* | 3399 | *15.96* | 5461 | *25.64* |
| 1960 | 20344 | 1886 | *9.27* | 3451 | *16.96* | 5337 | *26.23* |
| 1961 | 21130 | 2160 | *10.22* | 3602 | *17.05* | 5762 | *27.27* |
| 1962 | 23316 | 2280 | *9.78* | 3301 | *14.16* | 5581 | *23.94* |
| 1963 | 27858 | 1494 | *5.36* | 3241 | *11.63* | 4735 | *17.00* |
| 1964 | 29255 | 1213 | *4.15* | 2023 | *6.92* | 3236 | *11.06* |
| 1965 | 25535 | 267 | *1.05* | 922 | *3.61* | 1189 | *4.66* |
| 1956–65 | 228328 | 16894 | *7.40* | 26893 | *11.78* | 43787 | *19.18* |

| Year | Whalebone Whales | | | | | | |
|---|---|---|---|---|---|---|---|
| | World | Chile | | Perú | | Chile and Perú | |
| | | Nos | % | Nos | % | Nos | % |
| 1956 | 39472 | 462 | *1.17* | 8 | *0.02* | 470 | *1.19* |
| 1957 | 39834 | 213 | *0.53* | 0 | *0.00* | 213 | *0.53* |
| 1958 | 42229 | 255 | *0.60* | 0 | *0.00* | 255 | *0.60* |
| 1959 | 43075 | 170 | *0.39* | 1 | *0.00* | 171 | *0.40* |
| 1960 | 43145 | 198 | *0.46* | 0 | *0.00* | 198 | *0.46* |
| 1961 | 44511 | 174 | *0.39* | 0 | *0.00* | 174 | *0.39* |
| 1962 | 42774 | 58 | *0.14* | 0 | *0.00* | 58 | *0.14* |
| 1963 | 35721 | 49 | *0.14* | 0 | *0.00* | 49 | *0.14* |
| 1964 | 33746 | 295 | *0.87* | 43 | *0.13* | 338 | *1.00* |
| 1965 | 38983 | 1081 | *2.77* | 367 | *0.94* | 1448 | *3.71* |
| 1956–65 | 403490 | 2955 | *0.73* | 419 | *0.10* | 3374 | *0.84* |

Caleta Quintay (33°11'S, 71°42'W) six miles south of Valparaiso, and at Caleta Molle three miles south of Iquique (20°15'S, 70°08'W). In Perú the station of Consorcio Ballenero lies about four miles south of Pisco (13°46'S, 76°12'W) at the mouth of Paracas Bay; there is a small station belonging to Cía Marítima Pesquera at Chancay (11°35'S, 77°17'W) some 25 miles north of Callao, and the station of Cia Ballenera del Norte is at Tierra Colorada about four miles west of Paita (05°09'S, 81°08'W). In the present series of papers the stations will be known by the places whose geographical positions have been given, as in Fig. 1.

Whaling is regulated by the Permanent Commission for the Exploitation and Conservation of the Marine Resources of the South Pacific, set up in 1952 by agreement between the governments of Chile, Ecuador and Perú. Knowledge of the whale stocks at that time (reviewed by Clarke, 1962a) was scanty, being confined to what could be gleaned from catch statistics and the reports of pelagic whaling expeditions to the Southeast Pacific and from Townsend's charts (1935) of the captures of old-time whaling between 1761 and 1920. So in 1957 the governments approached the Food and Agriculture Organisation of the United Nations for assistance in starting whale investigations, with the result that organised research, designed to provide information which would lead to the rational exploitation of the stocks, was established between 1958 and 1961 when the first author of the present series of papers undertook a mission to Chile, Ecuador and Perú for the Food and Agriculture Organisation and under the Expanded Technical Assistance Programme of the United Nations. This undertaking was from the beginning planned and conducted as a co-operative, international enterprise in Chile, Ecuador and Perú, with co-ordinated research programmes and mutual exchange of national scientists, operating under the aegis of the Permanent Commission. Voyages were made to observe and mark whales, the compilation of detailed whale statistics was organised, and field laboratories for the examination of whale carcases were established at Talcahuano, Iquique, Pisco and Paita (Fig. 1). By the end of 1961 more than 2,000 sperm whales and a few whalebone whales had been biologically examined at the four laboratories.

At that time whale research in Chile was conducted jointly by the University of Chile and the Ministry of Agriculture. In Ecuador and Perú it was the responsibility of ministerial departments until in July 1960 in Perú the Marine Resources Research Institute (now the Instituto del Mar del Perú) was set up in Callao, followed in March 1961 by the National Fishery Institute of Ecuador at Guayaquil, when whale research became a part of the respective programmes of these institutes, which in their first years were financed jointly by the government and the United Nations Special Fund and operated by the Food and Agriculture Organisation (see Clarke, 1962b).

In September 1962 a contract was agreed between the Food and Agriculture Organisation and the British National Institute of Oceanography for a report to be prepared on the whale data and specimens collected in Chile, Ecuador and Perú between 1958 and 1961. From this material there have now been published the results of whale observation and whale marking in 1958 and 1959 off the coast of Chile and Ecuador and around the Galápagos Islands (Clarke, 1962a), and a paper on Bryde's whale from the small amount of data on whalebone whales (Clarke & Aguayo, 1965).

The sperm whale data and collections comprise the main part of the material, and work on these began in March 1963 when two of us (Anelio Aguayo and Obla Paliza) had arrived at the National Institute of Oceano-

graphy as F.A.O. Fellowship-holders. Progress was interrupted early in October 1963 when Anelio Aguayo and Obla Paliza left the United Kingdom to return to Chile and Perú, but was resumed again when the first author returned to Chile during 1964 and 1965, sent by the National Institute of Oceanography on foreign service to work at the Estación de Biología Marina de Montemar as a guest of the University of Chile. At this time a report about progress with the work on sexual maturity, breeding and the sexual cycle was published (Clarke, Aguayo & Paliza, 1964). More recently an analysis of some of the material on parasites has been included in a paper on the stalked barnacle *Conchoderma* as an ectoparasite of whales (Clarke, 1966).

The material available to us has sampled sperm whale populations of the Humboldt Current off a coastline extending through two thousand miles of latitude, so that in most parts of the present collaboration our approach has been to show separately the results from Paita, Pisco, Iquique and Talcahuano, and then look for any differences which, other than differences in physiological condition explicable by migration or latitude, might suggest the presence of separate stocks in the region. Here it could have been wished that the data from Chile were as abundant as those from Perú, but for various excellent reasons this has not been possible. However, our impression at the present stage of the work (January, 1967) is that the whales caught from these four localities are probably from the same continuous stock. Accordingly, for work so far completed, we have followed up the local analysis by lumping the results together as representative of the Southeast Pacific sperm whale stock as a whole, and these have been used wherever possible for comparison with results from stocks investigated in other parts of the world.

Since the material contains few whaling returns (p. 13), and since the biological observations cover no more than two and one half years, we do not expect that the report, when completed, will itself have said much on the effects of whaling on the stock, which in Perú have already been studied by Saetersdal, Mejia & Ramírez (1963) using an analysis of all the available whaling statistics. But we hope that the report will have provided a basis of information for future work on the management of the Southeast Pacific stock, and have delineated as far as possible its characteristics and relationships, as well as contributing generally to our knowledge of the biology of the sperm whale.

The report is expected to be published as a series of papers where it is hoped to maintain the present collaboration so far as circumstances allow. The first part is the present general introduction, and includes our acknowledgments to those who have helped with the project, and an indication of the material analysed and the methods employed. It is immediately followed by the second part on size range, external characters and teeth. Other parts are in various stages of preparation and will be published as they are finished.

**Acknowledgments**

These acknowledgments refer to assistance in getting the information from sperm whale carcases which forms the basis of the present series of papers. We therefore make no special mention of Ecuador where no whaling stations that could provide material are at present operating, but we shall eventually be taking account of the results of sperm whale observation conducted from Chile and from Ecuador in 1958 and 1959, and so we wish to recall here that the great help given by Chilean and Ecuadorean authorities in providing voyages to observe and mark whales has earlier been acknowledged by the first author (Clarke, 1962a).

Many people have helped towards the setting up between 1958 and 1961 of the research organisations in Chile and Perú which provided the sperm whale material reviewed below, and to name all of them would require a very long list indeed. We gratefully recall the active support at that time of successive Ministers of Agriculture in Chile, Mr. Elzo Pertuisset, Mr. Jorge Saelzer and Mr. Manuel Casanueva; and, in Perú, of the Minister of the Navy, Admiral Guillermo Tirado, the Ministers of Agriculture, Mr. Enrique Labarthe followed by Mr. Emilio Foley, and the Secretary General of Agriculture, Mr. Jacob Zender. Among those who helped much towards finding equipment and staff for the field laboratories were the Directors of Fisheries in Chile and in Perú, respectively Mr. Moisés Hernández and Dr. Cristóbal Vecorena, and the Director of the Marine Biological Station of the University of Chile at Montemar, Dr. Parmenio Yañez. These gentlemen also welcomed the first author with office and laboratory facilities at Valparaiso, Lima and Montemar, and to them, and to Dr. Walter Fischer and Mr. Héctor Etcheverry who were successively Directors at Montemar during his return to Chile in 1964 and 1965, he extends his best thanks for hospitality and unfailing collaboration. Similarly Anelio Aguayo and Obla Paliza wish to thank Dr. G. E. R. Deacon, Director of the National Institute of Oceanography in the United Kingdom, who with his colleagues warmly received them during their stay in 1962 and 1963.

The investigations were carried out under the aegis of the Permanent Commission of the South Pacific, and we owe much to the assistance of Mr. Mario Astorga of Chile, Secretary General of the Permanent Commission, and to his successor in 1959, Dr. Galo Leoro of Ecuador. We are especially grateful for the vigorous encouragement and support of Admiral Mariano Melgar, President of the Peruvian Section of the Permanent Commission at that time, and also President of the Hydrobiological Council of Perú which until 1961 co-ordinated the whale research in Perú. Unflagging help came also from the Secretaries of the Chilean and Peruvian Sections of the Permanent Commission, respectively Mr. Armando Scaglia and Commander Juan Manuel Castro.

In the Food and Agriculture Organisation, the former Director of

Fisheries, Dr. D. B. Finn, his deputy Mr. F. E. Popper and the Chiefs of the Fishery Biology Branch, successively Dr. G. L. Kesteven and Dr. S. J. Holt, gave much encouragement to the organisation of whale research in South America as a group-country project with an international programme; and we benefited much from the advice and experience of the FAO Regional Fisheries Officer for Latin America (Southern Zone), Mr. Jorge d'Alarcao. The Director until 1964 of the Marine Resources Research Institute at Callao, Dr. Trygve Sparre, kindly made available to us the biological material and data from Perú.

The laboratories at four of the whaling stations in Chile and Perú were equipped and manned from government or university funds, but they were constructed at the expense of the whaling industry, which has not only given facilities on the flensing platforms but has been much interested in our work and extended every kind of co-operation. We would like therefore to record our gratitude, in Chile, to the late Mr. Hellmut Heinsen, formerly managing director of Compañía Industrial, and to Mr. Manuel Labra who has succeeded him, and to the brothers Macaya of Macaya Hermanos y Cía; and, in Perú, to Mr. José Rosas, managing director of Consorcio Ballenero, and to Mr. Cristóbal Rosas and Dr. Rafael Manrique, who were successively managing directors of Cía Ballenera del Norte.

Finally we acknowledge the enthusastic co-operation of the biologists who shared with us the work of examining carcases at the whaling stations. These colleagues are Mr. Sergio Basulto (Iquique, 1960; Talcahuano, 1961) and Mr. Ramón Buzeta (Talcahuano, 1961) in Chile; and Mr. León Kostritsky (Paita, 1959), Mr. Jorge Mejía (Paita, 1960 and 1961), Mr. Pedro Ramírez (Paita, 1959 and 1960; Pisco, 1960), Mr. Julio Valdivia (Paita, 1960 and 1961) and Mr. Enrique Vinatea (Pisco, 1961) in Perú.

Other acknowledgments will be found in the text of the present series of papers.

## Material

The bulk of the data from Chile and Perú was received at the National Institute of Oceanography in February and March 1963. They referred to the biological examination of 2,162 sperm whale carcases, as tabulated and used in our progress report (Clarke, Aguayo & Paliza, 1964). More data arrived in November 1963, including those on 104 whales completing a year's observations at Pisco after August 1961. In Chile during 1964 we decided to include these, although this meant reworking the analyses then completed. Thus our material now refers to 2,266 sperm whales, comprising 1,295 males and 971 females. Their provenance is shown in Table 2. Chile has provided 253 whales and Perú 2,013. We are fortunate in that the material was collected during all months of the year, since there is no close season for sperm whaling in Chile and Perú at the present time.

Specimens associated with these data include some 400 teeth for age de-

Table 2. *Sperm whales biologically examined in Chile and Perú between 1959 and 1961.*

| Year | Perú | | | | Chile | | | | Totals | | Grand Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Paita 05°09′S, 81°08′W | | Pisco 13°46′S, 76°12′W | | Iquique 20°15′S, 70°08′W | | Talcahuano 36°40′S, 73°10′W | | | | |
| | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | |
| 1959 | 230 Jun–Dec | 151 Jun–Dec | | | | | | | 230 | 151 | 381 |
| 1960 | 341 Jan–Dec | 251 Jan–Dec | 91 Aug–Dec | 58 Aug–Dec | 124 Apr–Dec | 84 Mar–Dec | | | 556 | 393 | 949 |
| 1961 | 284 Jan–Dec | 283 Jan–Dec | 193 Jan–Dec | 131 Jan–Dec | — | — | 32 Mar–Jun | 13 Mar–Apr | 509 | 427 | 936 |
| 1959–1961 | 855 | 685 | 284 | 189 | 124 | 84 | 32 | 13 | 1295 | 971 | 2266 |

Table 3. *Sperm whales whose body proportions were measured in Chile and Perú between 1959 and 1964.*

| Whales | | Paita | | | | Pisco | | | Iquique | Talca-huano | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1959 | 1960 | 1961 | 1964 | 1960 | 1961 | 1962 | 1960 | 1961 | |
| ♂♂ | Foetal | 13 | 4 | 4 | | 2 | 10 | 7 | 4 | | 44 |
| | Postnatal | 8 | 2 | 2 | | | 7 | 5 | 5 | 1 | 30 |
| ♀♀ | Foetal | 9 | 2 | 4 | | 4 | 7 | 8 | 3 | | 37 |
| | Postnatal | | 1 | 6 | 2 | | 4 | 4 | 3 | | 20 |
| Totals | | 30 | 9 | 16 | 2 | 6 | 28 | 24 | 15 | 1 | 131 |

termination, 1010 testis samples, stomach contents, collections of parasites, and pathological material. The parasites and certain other specimens have been submitted to the British Museum (Natural History) for expert identification.

The data on body proportions are summarised in Table 3. Proportional measurements of 66 foetal and 39 postnatal sperm whales were recorded in Chile and Perú between 1959 and 1961, but we have been able usefully to augment these with further measurements from Perú of 15 foetuses and nine postnatal animals in 1962, and of two postnatal animals in 1964.

There are also some detailed whaling returns from the station at Chancay in Perú for December 1958 to the end of 1961, and from Iquique and Talcahuano in Chile where the returns are for 1962 but have been included.

All this material has been lent to the National Institute of Oceanography: it remains the property of the governments of Chile and Perú.

## Methods

The methods employed call for no special mention here, except that other workers may be interested in the details of the routine biological examination of sperm whale carcases recorded at the field laboratories in Paita, Pisco, Iquique and Talcahuano. Notes from the rough pocket-books employed on the flensing platform were transferred to bound foolscap ledgers ruled in columns as indicated below, the numbers referring to the columns. The complete routine examination comprised some 20 groups of observations for males and some 30 for females.

*Males:*

1. *Serial numbers.* Whales were numbered as examined, irrespective of sex. The prefixes Pa, Pi, I, and T identify whales from Paita, Pisco, Iquique, and Talcahuano respectively.
2. *Date.*
3. *Length* in feet.
4. *Length* in metres.
5. *Sexual maturity.* Entries are made as immature, puberal, or mature, but this column is not completed until the testis samples have been histologically examined.
6. *Blubber thickness.* Measured in centimetres on the flank at the level of the dorsal fin.
7. *Blubber thickness.* Measured ventrally near the anus.
8. *Oval scars.* Their abundance on the body was estimated as very few, few, moderate, many or very many, as giving a rough idea of age. Estimates of the abundance of
9. *Cephalopod scars* (recorded separately as linear or circular) were made for the same purpose.

10. *Head whorl.* This configuration of pigment flecks on the forehead was recorded as not developed, slightly developed, moderately developed, or well developed, to investigate any association of the head whorl with age.

11. *Stomach contents*
    (a) The quantity of food in the first and second stomachs was estimated as nil, little, moderate or much.
    (b) The numbers of squids present were recorded in four size groups, as small (0.6—0.9 m standard length), medium (0.9—1.5 m), medium-large (1.5—1.8 m), and large (1.8—2.4 m).
    (c) For species distribution of the squids they were recorded as comprising so many different 'types', A, B, C etc., and specimens of these types were collected for eventual identification when the squid were fresh enough.
    (d) Food other than squids was recorded if present.
    (e) The kinds and quantities of indigestible remains, such as squid beaks, pens, and eye lenses were recorded, and occasional samples taken.
    (f) Stomach parasites (nematode worms and others) were noted and sampled.

12. *External genitals.* The length of the penis, if fully extraverted, was noted, and also the presence of any genital grooves.
13. *Testes.* The volumes in cubic centimetres of the left and right separately, as length x breadth x thickness.
14. *Testes.* The weights in kilograms of the left and right separately. A sample of the testis fixed in Bouin's fluid was invariably taken.
15. *Fusion of the epiphyses to the centra in the vertebral column.* Several thoracic, lumbar, and caudal vertebrae were examined with an axe.
16. *Physical maturity.* From the observations in column 15, the whales were recorded as immature or mature.
17. *Teeth.* The dental formula was recorded, including a note of the number of mandibular teeth which had not erupted.
    The tenth mandibular tooth on the left side was removed whenever possible in each whale, and preserved for age determination studies.
18. *Cyamid parasites.* The presence or absence of cyamids on the body surface was noted, and samples taken.
19. *Remarks.* This was a large column which always contained observations on the following:

    (a) *Colour of the body surface,* describing all unpigmented areas and their patterns.
    (b) *Dorsal fin.* Estimated as being slightly, moderately, or well-developed. A rugose patch of skin or callus was noted on the dorsal fin when present.

(c) *Number of posterior dorsal humps.*

(d) *Throat grooves.* Notes and a sketch made to show variation.

(e) *Accessory grooves.* A note of any additional grooves on the body surface.

(f) *Other observations* which might include notes on parasites (such as *Conchoderma* on the teeth, *Pennella* in the skin, *Phyllobothrium* cysts in the blubber, or cestodes in the intestines); or on disease; or on deformities or injuries; or on the presence of ambergris.

*Females:*

1—4. As for males.

5. *Sexual maturity.* Recorded as immature or mature after inspection of the ovaries.

6—11. As for males.

12. *Mammary glands.* The nipples were recorded as whether or not protruding. After the whale had been flensed, the width, depth, colour, and appearance of the gland were noted. If lactating, the quantity of milk present was estimated.

13. *Genitals.* Externally, the presence or absence of vaginal mucus was noted. Internally, the collapsed diameters of the corpus and the two cornua of the uterus were recorded.

14. *Foetus.* After searching the uterus, a foetus was recorded as present, absent, or 'not ascertained'. If present, the sex, length, and (sometimes) the colour pattern were noted.

15—24. *Ovaries.* After weighing, these were sliced by hand with butcher's knives into slices approximately one half-centimetre thick. Notes were made as follows:

15. Weight in kilograms.

16—19. *Ovary I.*

16. Numbers and diameters of functional corpora lutea.

17. Numbers and diameters of regressing corpora.

18. Numbers and diameters of regressed corpora.

19. Estimate of the abundance and size of the follicles, and a note of the diameter of the largest.

20—23. *Ovary II.* As above.

24. Total number of corpora lutea present in both ovaries.

25—29. As for males 15—19.

## Part II. Size range, external characters and teeth

### Introduction

There are analysed here the data on length, external characters and teeth in 2,266 sperm whales, comprising 1,295 males and 971 females, examined in Chile and Perú between 1959 and 1961 (Table 2). Body proportions will be the subject of a separate paper now in preparation. The analysis is confined to postnatal animals, because Paliza (1964) has already described the development and variation of the external characters in foetal sperm whales, from 157 foetuses examined in Perú.

In a stock exploited by whaling, the size distribution of the catch is not likely to be of value as a possible racial characteristic, but external characters and dental formulae may be expected to give useful information on stock limits. Thus the present paper is firstly a description of the Southeast Pacific sperm whale stock in terms of the variation of these characters, and secondly an attempt to compare this variation with published results from other stocks where appreciable numbers of whale have been examined.

In the Antarctic and South Indian Ocean, Matthews (1938) dealt with external characters and dental formulae, and in the Antarctic, Ohno & Fujino (1952) described only colour among the external characters. In the North Pacific, Omura (1950) described colour and dental formulae for sperm whales from the coast of Japan; Ivanova (1955) included information on the number of teeth in her account of the body proportions of sperm whales from the Kurile Islands; and Gudkov (1963) described colour variations from the Northwest Pacific. In the North Atlantic, Clarke (1956) described the variation of external characters and teeth in sperm whales from the Azores. Compared with the present sample from the Southeast Pacific, the amount of data available to these authors was not large, being from whales ranging in number from 33 to 385 of males and females combined. General accounts of the external characters and teeth in sperm whales, and specific references to these in one or a few whales, have been reviewed by Clarke (1956) and for the most part are not discussed here.

### Size range

Under the regulations of the Permanent Commission for the Exploitation and Conservation of the Marine Resources of the South Pacific, the minimum size at which sperm whales may be taken is 9.1 metres or 30 feet, so that more females appear in the catches from Chile and Perú than in those from most other sperm whaling grounds. This may be seen in the Tables 4—6 and the Figs. 2—3 which present the length frequencies of the 1,295 males and 971 females measured by biologists at Paita, Pisco, Iquique, and Talcahuano between 1959 and 1961.

Saetersdal, Mejía & Ramírez (1963) have earlier shown that in Perú at Paita and Pisco in 1960 and 1961, being those years where length statistics

Table 4. *Males. Length frequencies of whales examined at Paita, Pisco, Iquique and Talcahuano between 1959 and 1961. The actual numbers of whales are shown in italics.*

| Length m | Paita | | | | Pisco | | | Iquique | Talcahuano |
|---|---|---|---|---|---|---|---|---|---|
| | 1959 *230* % | 1960 *341* % | 1961 *284* % | 1959-61 *855* % | 1960 *91* % | 1961 *193* % | 1960-61 *284* % | 1960 *124* % | 1961 *32* % |
| 6.5 | | | | | | 0.5 | 0.4 | | |
| 7.0 | | | | | | 1.6 | 1.1 | | |
| .5 | | | 0.3 | 0.1 | 1 | 1.0 | 1.1 | 0.8 | |
| 8.0 | 0.4 | 0.6 | 0.7 | 0.6 | 3 | | 1.1 | 3.2 | |
| .5 | 0.4 | 1.2 | 2.5 | 1.4 | 6 | 2.1 | 3.2 | 4.8 | 6 |
| 9.0 | 1.7 | 1.8 | 2.5 | 2.0 | 2 | 4.1 | 3.5 | 5.6 | 3 |
| .5 | 5.7 | 4.1 | 13.4 | 7.6 | 3 | 2.6 | 2.8 | 3.2 | 6 |
| 10.0 | 7.4 | 12.3 | 12.3 | 11.0 | 13 | 7.8 | 9.5 | 9.7 | 6 |
| .5 | 11.7 | 11.4 | 17.3 | 13.5 | 7 | 10.4 | 9.2 | 5.6 | 13 |
| 11.0 | 8.7 | 13.8 | 10.6 | 11.3 | 7 | 13.5 | 11.3 | 12.1 | 6 |
| .5 | 7.0 | 7.3 | 6.3 | 6.9 | 9 | 6.7 | 7.4 | 11.3 | 6 |
| 12.0 | 4.8 | 7.9 | 2.8 | 5.4 | 7 | 5.2 | 5.6 | 5.6 | 13 |
| .5 | 5.7 | 6.7 | 2.1 | 4.9 | 6 | 4.7 | 4.9 | 2.4 | |
| 13.0 | 7.4 | 5.0 | 3.5 | 5.1 | 8 | 7.8 | 7.8 | 8.9 | 6 |
| .5 | 6.1 | 5.0 | 5.3 | 5.4 | 10 | 9.3 | 9.5 | 6.5 | 6 |
| 14.0 | 3.0 | 2.6 | 3.9 | 3.2 | 4 | 9.3 | 7.8 | 8.1 | 6 |
| .5 | 5.7 | 3.8 | 2.8 | 4.0 | 8 | 3.6 | 4.9 | 2.4 | 6 |
| 15.0 | 5.7 | 4.1 | 2.1 | 3.9 | 3 | 2.1 | 2.5 | 2.4 | 9 |
| .5 | 7.0 | 5.3 | 7.4 | 6.4 | 3 | 4.7 | 4.2 | 4.8 | 3 |
| 16.0 | 7.4 | 4.4 | 3.2 | 4.8 | 1 | 1.6 | 1.4 | 1.6 | 3 |
| .5 | 2.6 | 2.3 | 1.0 | 2.0 | | 0.5 | 0.4 | 0.8 | |
| 17.0 | 1.3 | 0.3 | | 0.5 | | 1.0 | 0.7 | | |
| .5 | 0.4 | | | 0.1 | | | | | |
| | 100.0 | 99.9 | 100.0 | 100.1 | 101 | 100.1 | 100.3 | 99.8 | 98 |

Table 5. *Females. Length frequencies of whales examined at Paita, Pisco, Iquique and Talcahuano between 1959 and 1961.*

| Length m | Paita | | | | Pisco | | | Iquique | Talcahuano |
|---|---|---|---|---|---|---|---|---|---|
| | 1959 *151* % | 1960 *251* % | 1961 *283* % | 1959-61 *685* % | 1960 *58* % | 1961 *131* % | 1960-61 *189* % | 1960 *84* % | 1961 *13* % |
| 6.5 | | | | | | | | | |
| 7.0 | | | | | | | | | |
| .5 | | | 0.4 | 0.1 | 5 | 4.6 | 4.8 | 1 | |
| 8.0 | | 2.4 | 2.1 | 1.8 | 3 | 3.1 | 3.2 | 4 | |
| .5 | 4.0 | 3.2 | 6.7 | 4.8 | 12 | 3.8 | 6.4 | 8 | 23 |
| 9.0 | 7.3 | 15.1 | 11.7 | 12.0 | 19 | 21.4 | 20.6 | 17 | 15 |
| .5 | 29.8 | 28.7 | 33.2 | 30.8 | 21 | 23.7 | 22.8 | 20 | 15 |
| 10.0 | 33.8 | 32.3 | 31.4 | 32.3 | 33 | 26.0 | 28.0 | 25 | 23 |
| .5 | 19.9 | 15.9 | 10.2 | 14.5 | 5 | 11.5 | 9.5 | 17 | 15 |
| 11.0 | 4.6 | 2.0 | 3.5 | 3.2 | 2 | 3.8 | 3.2 | 6 | |
| .5 | 0.7 | 0.4 | 0.7 | 0.6 | | 1.5 | 1.1 | 2 | 8 |
| | 100.1 | 100.0 | 99.9 | 100.1 | 100 | 100.2 | 100.1 | 100 | 99 |

Table 6. *Length frequencies of sperm whales examined in Chile and Perú between 1959 and 1961.*

| Length m. | Males | | Females | |
|---|---|---|---|---|
| | No. | % | No. | % |
| 6.5 | 1 | 0.08 | 1 | 0.10 |
| 7.0 | 3 | 0.23 | | |
| .5 | 5 | 0.39 | 11 | 1.13 |
| 8.0 | 12 | 0.93 | 21 | 2.16 |
| .5 | 29 | 2.24 | 55 | 5.66 |
| 9.0 | 37 | 2.86 | 137 | 14.11 |
| .5 | 80 | 6.18 | 273 | 28.12 |
| 10.0 | 134 | 10.35 | 298 | 30.69 |
| .5 | 155 | 11.97 | 133 | 13.70 |
| 11.0 | 143 | 11.04 | 33 | 3.40 |
| .5 | 95 | 7.34 | 9 | 0.93 |
| 12.0 | 75 | 5.79 | | |
| .5 | 59 | 4.55 | | |
| 13.0 | 79 | 6.10 | | |
| .5 | 88 | 6.79 | | |
| 14.0 | 53 | 4.09 | | |
| .5 | 54 | 4.17 | | |
| 15.0 | 45 | 3.47 | | |
| .5 | 74 | 5.71 | | |
| 16.0 | 48 | 3.71 | | |
| .5 | 19 | 1.47 | | |
| 17.0 | 6 | 0.46 | | |
| .5 | 1 | 0.08 | | |
| Total | 1295 | 100.00 | 971 | 100.00 |

of the catch were sufficiently detailed to compare with the lengths recorded by biologists, the length distribution of the samples fairly represented that of the catch. For Chile, the numbers of whales examined at Iquique, and especially at Talcahuano, are really too small for a comparison with the catch from these stations.

In the percentage length frequencies of the samples by localities (Fig. 2), there are indications at Paita over the three years from 1959 to 1961 of a reduction in the classes of larger whales over about 12 m, and this is likely to be an effect of whaling, although it is not apparent at Pisco between 1960 and 1961. At Paita in 1960, and again in 1961, there are more of the shorter younger whales between 8 and 12 m than at Pisco in the same year, and Iquique too in 1961 shows fewer of the smaller whales: this suggests that in the stock at large there is a progressive diminution in the proportion of younger, smaller whales from north to south of the region. For females the size range is so restricted that a comparison of length frequencies in the half-metre groups used here can show little of value.

In Table 6 and Fig. 3 the length frequencies from Chile and Perú are combined. The inset in Fig. 3 shows the length frequencies of the catch (comprising 417 males and 202 females) at Fayal in the Azores, during the period 1949 to 1954 when the stock of sperm whales there showed no indication of being overfished (Clarke, 1956). Although there may be differences

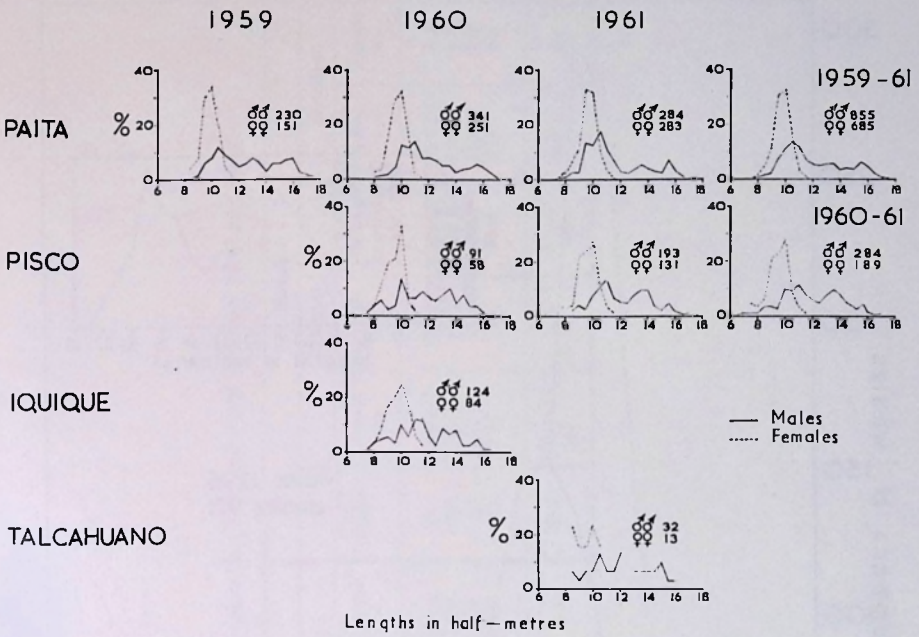


Fig. 2. Percentage length frequencies of sperm whales examined at Paita, Pisco, Iquique and Talcahuano between 1959 and 1961.

in the local distribution of the sizes of whales relative to the coast, and differences in the range of catching, it is striking to note the much greater proportion in the Azores catch of the larger whales, which are those most sought after in both localities.

A breakdown of the length frequencies by months as well as years at each of the four localities in Chile and Perú is given in the Appendix (Tables A1—4, B1—3, C1, and D1).

Regarding the actual size range of sperm whales available off Chile and Perú, Table 7 shows the largest and smallest whales measured by biologists between 1959 and 1961. The sizes of the smallest whales examined are included to show the range, and by themselves have no other significance in this context. Size at birth is important, and we have explained in a progress report how we have estimated this to be 4.02 m (13 ft. 2 in.) for both sexes combined, with the male neonates on average 0.12 m larger than the females, supposing the same gestation time for both sexes (Clarke, Aguayo & Paliza, 1964). The length at birth will be examined again in a separate paper being prepared on breeding. Differences in the lengths of the largest whales measured respectively at Paita, Pisco, Iquique, and Talcahuano are explicable by differences in the size of the sample at each locality. The largest male from the whole region measured 17.3 m (57 ft.) and was still capable of

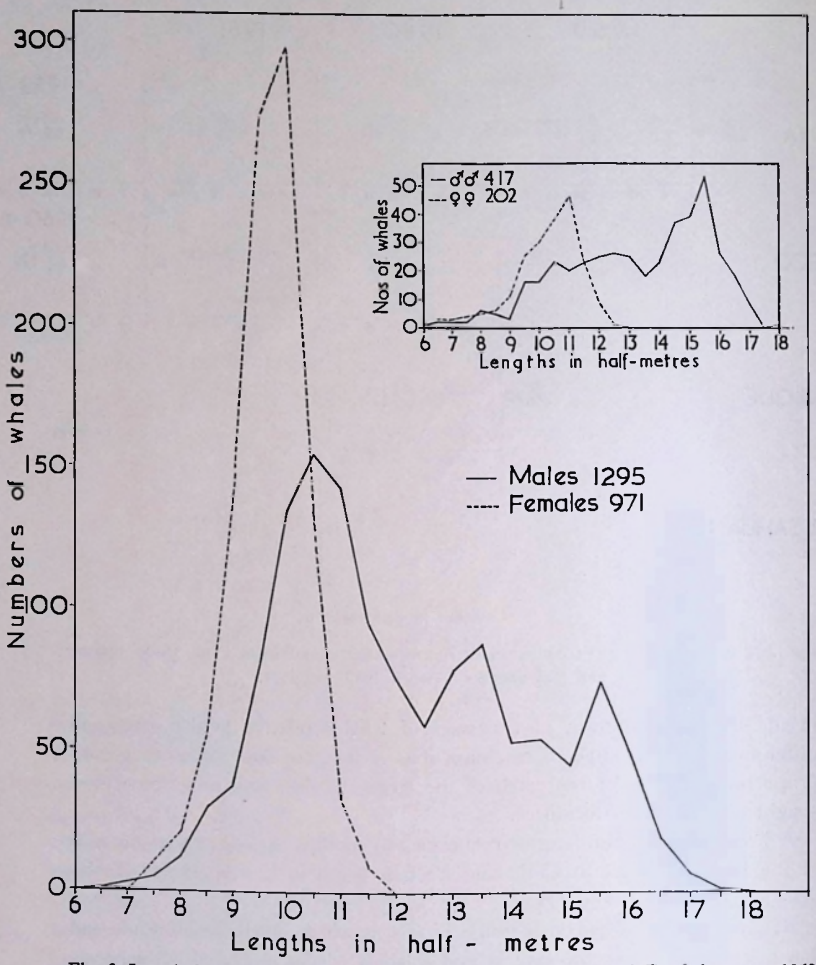


Fig. 3. Length frequencies of sperm whales examined in Chile and Perú between 1959 and 1961. An inset shows the length frequencies of the catch at Fayal in the Azores between 1949 and 1954 (from Clarke, 1956, Fig. 2).

further growth. Length frequencies of the catch of 8,766 males from Paita (1958—1961) and Pisco (1956—1961) do in fact record one larger whale, in the group 18.0—18.4 m (Saetersdal, Mejía & Ramírez, 1963, Anexos IXA y IXB), and this must have been approaching the maximum size attainable for sperm whales, for Clarke (1956) has noticed that of 68,765 measurements of male sperm whales published in the *International Whaling Statistics,* only 84 or 0.122 % exceed 59 ft. (18.0 m). The largest females measured by biologists in Chile and Perú were two whales of 11.7 m (38 ft.), one of them

Table 7. *Largest and smallest whales measured by biologists in Chile and Perú between 1959 and 1961.*

| Locality | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of whales | Largest | | | Smallest | | No. of whales | Largest | | | Smallest | |
| | | Serial no. | Length m. | Physical maturity | Serial no. | Length m. | | Serial no. | Length m. | Physical maturity | Serial no. | Length m. |
| Paita | 852 | Pa148 | 17.3 | Imm. | Pa1447 | 7.4 | 684 | Pa1353 | 11.7 | Imm. | Pa1225 | 7.7 |
| Pisco | 284 | Pi178 | 17.0 | Imm. | Pi361 | 6.4 | 189 | Pi438 | 11.5 | Mat. | Pi417 | 6.6 |
| Iquique | 124 | I83 | 16.3 | Imm. | I207 | 7.4 | 84 | I67 | 11.7 | Mat. | I209 | 7.7 |
| Talcahuano | 32 | T41 | 15.9 | No obs. | T17 | 8.5 | 13 | T32 | 11.5 | Mat. | T14 | 8.4 |
| Chile and Perú | 1292 | Pa148 | 17.3 | Imm. | Pi361 | 6.4 | 970 | Pa1353<br>I67 | 11.7 | Imm.<br>Mat. | Pi417 | 6.6 |

physically mature and the other immature. The largest female sperm whale so far known to have been reliably measured was a 12.30 m (40 ft. 4 in.) specimen from the Azores (Clarke 1956) but the catch statistics from Paita and Pisco mentioned above record 15 individuals in the group 12.0—12.4 m and two in the largest group 12.5—12.9 m, from a total of 7,054 females. Whilst these figures from the catch statistics are not altogether reliable as maxima in themselves, and they are not here claimed as such, they do show, when taken together with the data in Table 7, that the maximum sizes of male and female sperm whales in the Southeast Pacific are not less than those attained in other parts of the world.

## External characters

Those external characters of the sperm whale which exhibit variation and are discussed here comprise the colour markings on the body surface, including the spiral configuration sometimes found on the forehead, called the head whorl; the size of the dorsal fin and the number of humps posterior to it; and the number and arrangement of grooves on the throat, and of certain accessory grooves on the body surface.

### *Colour*

Full notes on colour, often supplemented by sketches, are available from 1,285 males and 968 females. On analysing the data, it became apparent that the seven categories of colour markings, employed by Clarke (1956, p. 245, Table 4) to describe 33 sperm whales from the Azores, were not sufficient to contain the variation in the present large sample. An extended classification of 18 categories was therefore devised, which we believe can be used to describe completely the colour variation in a population of sperm whales. In Table 8—10 these categories are defined: the first five are the same as Clarke's, but Clarke's category no. 6 on the pigmentation of the lower jaw has been here sub-divided into nos. 6—9, and his category no. 7 on the pigmentation of both jaws has become our no. 10, whilst the remaining eight categories are additional. Fig. 4 attempts to illustrate the category definitions with typical examples from sketches made on the flensing platform. As Matthews (1938) and Clarke have described, ventral white or grey splashes (no. 2), ventro-lateral white or grey streaks (no. 3), and the combination of these (no. 4), are markings which vary a great deal in form and extent in those whales which bear them, so that Fig. 4 includes a series of these (nos. 2a-e, 3a-e, and 4a-f) selected at random.

The percentage frequencies of the various colour markings in whales from Paita, Pisco, Iquique, and Talcahuano are given in Tables 8 and 9 for males and females respectively, and they are shown by a histogram method in Figs.

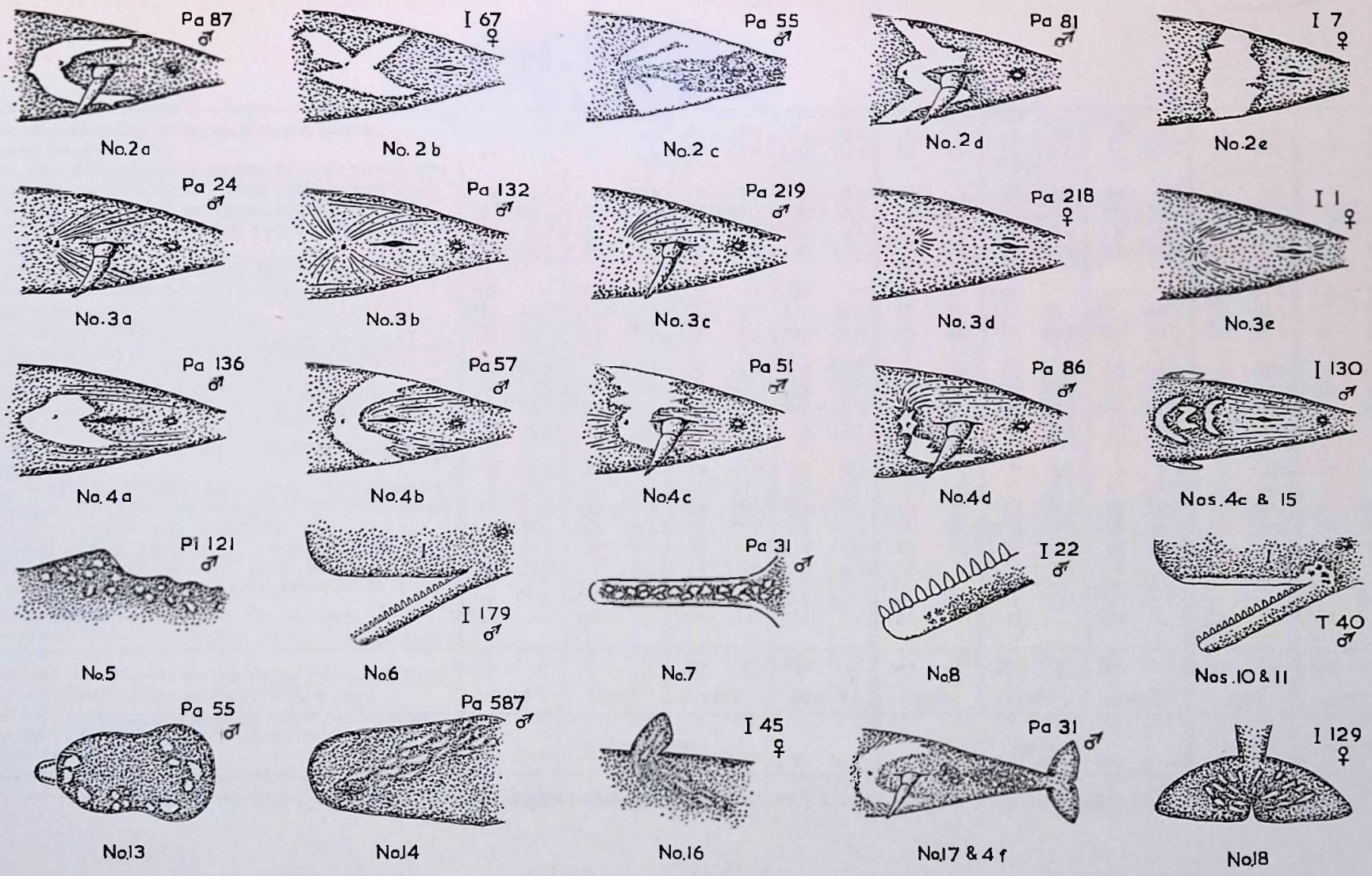


Fig. 4. Examples of colour markings (nos. 2—18 in Tables 8, 9, and 11) in whales examined in Chile and Perú between 1959 and 1961.

Table 8. *Males. Colour variations of whales examined in Chile and Perú between 1959 and 1961.*

| Colour marking | Paita | | | | | | | | Pisco | | | | | | Iquique | | Talcahuano | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1959 | | 1960 | | 1961 | | 1959–61 | | 1960 | | 1961 | | 1960–61 | | 1960 | | 1961 | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| Number of whales whose colour was recorded | 226 | | 339 | | 280 | | 845 | | 91 | | 193 | | 284 | | 124 | | 32 | |
| 1. Uniformly pigmented except for slight streaking on the body or (marking No. 10) white about the jaws | 1 | *0.4* | 4 | *1.2* | 8 | *2.9* | 13 | *1.5* | 2 | *2* | 4 | *2.1* | 6 | *2.1* | 0 | *0.0* | 0 | *0* |
| 2. Ventral white or grey splash in the umbilical region | 29 | *12.8* | 36 | *10.6* | 9 | *3.2* | 74 | *8.8* | 16 | *18* | 30 | *15.5* | 46 | *16.2* | 34 | *27.4* | 5 | *16* |
| 3. Ventro-lateral white or light grey streaks | 110 | *48.7* | 177 | *52.2* | 165 | *58.9* | 452 | *53.5* | 60 | *66* | 119 | *61.7* | 179 | *63.0* | 57 | *46.0* | 10 | *31* |
| 4. Ventral white splash and ventro-lateral streaks both present | 81 | *35.8* | 115 | *33.9* | 93 | *33.2* | 289 | *34.2* | 13 | *14* | 38 | *19.7* | 51 | *18.0* | 33 | *26.6* | 17 | *53* |
| 5. Light flecking in the region of dorsal fin or posterior dorsal humps | 3 | *1.3* | 14 | *4.1* | 14 | *5.0* | 31 | *3.7* | 1 | *1* | 6 | *3.1* | 7 | *2.5* | 6 | *4.8* | 4 | *13* |
| 6. Lower jaw half-white downwards from alveolar margin but margin of upper jaw pigmented | 1 | *0.4* | 0 | *0.0* | 0 | *0.0* | 1 | *0.1* | 0 | *0* | 0 | *0.0* | 0 | *0.0* | 2 | *1.6* | 0 | *0* |
| 7. Lower jaw with white markings on ventral surface | 100 | *44.2* | 119 | *35.1* | 77 | *27.5* | 296 | *35.0* | 39 | *43* | 107 | *55.4* | 146 | *51.4* | 35 | *28.2* | 11 | *34* |
| 8. Tip of lower jaw white or with white markings | 5 | *2.2* | 0 | *0.0* | 17 | *6.1* | 22 | *2.6* | 0 | *0* | 2 | *1.0* | 2 | *0.7* | 35 | *28.2* | 10 | *31* |
| 9. Lower jaw completely white or whitish | 4 | *1.8* | 0 | *0.0* | 1 | *0.4* | 5 | *0.6* | 0 | *0* | 2 | *1.0* | 2 | *0.7* | 2 | *1.6* | 1 | *3* |
| 10. Lower jaw half-white downwards from alveolar margin and white margin to upper jaw | 223 | *98.7* | 333 | *98.2* | 268 | *95.7* | 824 | *97.5* | 89 | *98* | 187 | *96.9* | 276 | *97.2* | 120 | *96.8* | 29 | *91* |
| 11. White markings around the gape | 167 | *73.9* | 317 | *93.5* | 265 | *94.6* | 749 | *88.6* | 78 | *86* | 175 | *90.7* | 253 | *89.1* | 29 | *23.4* | 22 | *69* |
| 12. Dark markings on the palate | (1) | — | — | — | — | — | (1) | — | — | — | — | — | — | — | 30 | *24.2* | 7 | *22* |
| 13. White markings on forehead and/or snout (as distinct from head whorl) | 58 | *25.7* | 40 | *11.8* | 52 | *18.6* | 150 | *17.8* | 5 | *6* | 70 | *36.3* | 75 | *26.4* | 33 | *26.6* | 9 | *28* |
| 14. White or light markings on the top and/or sides of the head | 15 | *6.6* | 13 | *3.8* | 15 | *5.4* | 43 | *5.1* | 1 | *1* | 7 | *3.6* | 8 | *2.8* | 6 | *4.8* | 1 | *3* |
| 15. White or light markings on the throat and/or chest | 23 | *10.2* | 26 | *7.7* | 31 | *11.1* | 80 | *9.5* | 3 | *3* | 57 | *29.5* | 60 | *21.1* | 4 | *3.2* | 0 | *0* |
| 16. White or light markings on or around flippers or in axilla | 6 | *2.7* | 1 | *0.3* | 0 | *0.0* | 7 | *0.8* | 0 | *0* | 18 | *9.3* | 18 | *6.3* | 0 | *0.0* | 0 | *0* |
| 17. White or light markings on or around genitals. anus and/or post-anal ventral hump | 36 | *15.9* | 52 | *15.3* | 52 | *18.6* | 140 | *16.6* | 16 | *18* | 71 | *36.8* | 87 | *30.6* | 23 | *18.5* | 6 | *19* |
| 18. White or light markings on tailstock and/or flukes | 1 | *0.4* | 16 | *4.7* | 18 | *6.4* | 35 | *4.1* | 1 | *1* | 5 | *2.6* | 6 | *2.1* | 7 | *5.6* | 5 | *16* |

Table 9. *Females. Colour variations of whales examined in Chile and Perú between 1959 and 1961.*

| Colour marking | Paita | | | | | | | | Pisco | | | | | | Iquique | | Talcahuano | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1959 | | 1960 | | 1961 | | 1959-61 | | 1960 | | 1961 | | 1960-61 | | 1960 | | 1961 | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| Number of whales whose colour was recorded | 149 | | 251 | | 282 | | 682 | | 58 | | 131 | | 189 | | 84 | | 13 | |
| 1. Uniformly pigmented except for slight streaking on the body or (marking No. 10) white about the jaws | 6 | *4.0* | 16 | *6.4* | 11 | *3.9* | 33 | *4.8* | 1 | *2* | 1 | *0.8* | 2 | *1.1* | 1 | *1* | 0 | *0* |
| 2. Ventral white or grey splash in the umbilical region | 41 | *28.0* | 45 | *17.9* | 19 | *6.7* | 105 | *15.4* | 10 | *17* | 24 | *18.3* | 34 | *18.0* | 27 | *32* | 4 | *31* |
| 3. Ventro-lateral white or light grey streaks | 77 | *51.7* | 117 | *46.6* | 158 | *56.0* | 352 | *51.6* | 37 | *64* | 85 | *64.9* | 122 | *64.6* | 41 | *49* | 7 | *54* |
| 4. Ventral white splash and ventro-lateral streaks both present | 23 | *15.4* | 72 | *28.7* | 90 | *31.9* | 185 | *27.1* | 10 | *17* | 18 | *13.7* | 28 | *14.8* | 14 | *17* | 2 | *15* |
| 5. Light flecking in the region of dorsal fin or posterior dorsal humps | 2 | *1.3* | 1 | *0.4* | 9 | *3.2* | 12 | *1.8* | 0 | *0* | 6 | *4.6* | 6 | *3.2* | 4 | *5* | 1 | *8* |
| 6. Lower jaw half-white downwards from alveolar margin but margin of upper jaw pigmented | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0.0* | 0 | *0* | 0 | *0.0* | 0 | *0.0* | 2 | *2* | 0 | *0* |
| 7. Lower jaw with white markings on ventral surface | 54 | *36.2* | 69 | *27.5* | 74 | *26.2* | 197 | *28.9* | 23 | *40* | 48 | *36.6* | 71 | *37.6* | 17 | *20* | 3 | *23* |
| 8. Tip of lower jaw white or with white markings | 3 | *2.0* | 2 | *0.8* | 19 | *6.7* | 24 | *3.5* | 1 | *2* | 1 | *0.8* | 2 | *1.1* | 15 | *18* | 3 | *23* |
| 9. Lower jaw completely white or whitish | 4 | *2.7* | 3 | *1.2* | 0 | *0.0* | 7 | *1.0* | 0 | *0* | 1 | *0.8* | 1 | *0.5* | 4 | *5* | 2 | *15* |
| 10. Lower jaw half-white downwards from alveolar margin and white margin to upper jaw | 139 | *93.3* | 231 | *92.0* | 271 | *96.1* | 641 | *94.0* | 57 | *98* | 129 | *98.5* | 186 | *98.4* | 76 | *91* | 11 | *85* |
| 11. White markings around the gape | 102 | *68.5* | 214 | *85.3* | 266 | *94.3* | 582 | *85.3* | 54 | *93* | 120 | *91.6* | 174 | *92.1* | 41 | *49* | 10 | *77* |
| 12. Dark markings on the palate | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 12 | *14* | 1 | *8* |
| 13. White markings on forehead and/or snout (as distinct from head whorl) | 41 | *27.5* | 10 | *4.0* | 29 | *10.3* | 80 | *11.7* | 2 | *3* | 26 | *19.8* | 28 | *14.8* | 20 | *24* | 3 | *23* |
| 14. White or light markings on the top and/or sides of the head | 4 | *2.7* | 5 | *2.0* | 9 | *3.2* | 18 | *2.6* | 4 | *7* | 3 | *2.3* | 7 | *3.7* | 7 | *8* | 1 | *8* |
| 15. White or light markings on the throat and/or chest | 16 | *10.7* | 8 | *3.2* | 26 | *9.2* | 50 | *7.3* | 5 | *9* | 41 | *31.3* | 46 | *24.3* | 8 | *10* | 0 | *0* |
| 16. White or light markings on or around flippers or in axilla | 6 | *4.0* | 1 | *0.4* | 1 | *0.4* | 8 | *1.2* | 1 | *2* | 11 | *8.4* | 12 | *6.3* | 3 | *4* | 2 | *15* |
| 17. White or light markings on or around genitals, anus and/or post-anal ventral hump | 34 | *22.8* | 42 | *16.7* | 62 | *22.0* | 138 | *20.2* | 8 | *14* | 53 | *40.5* | 61 | *32.3* | 27 | *32* | 6 | *46* |
| 18. White or light markings on tailstock and/or flukes | 1 | *0.7* | 1 | *0.4* | 5 | *1.8* | 7 | *1.0* | 0 | *0* | 1 | *0.8* | 1 | *0.5* | 12 | *14* | 2 | *15* |

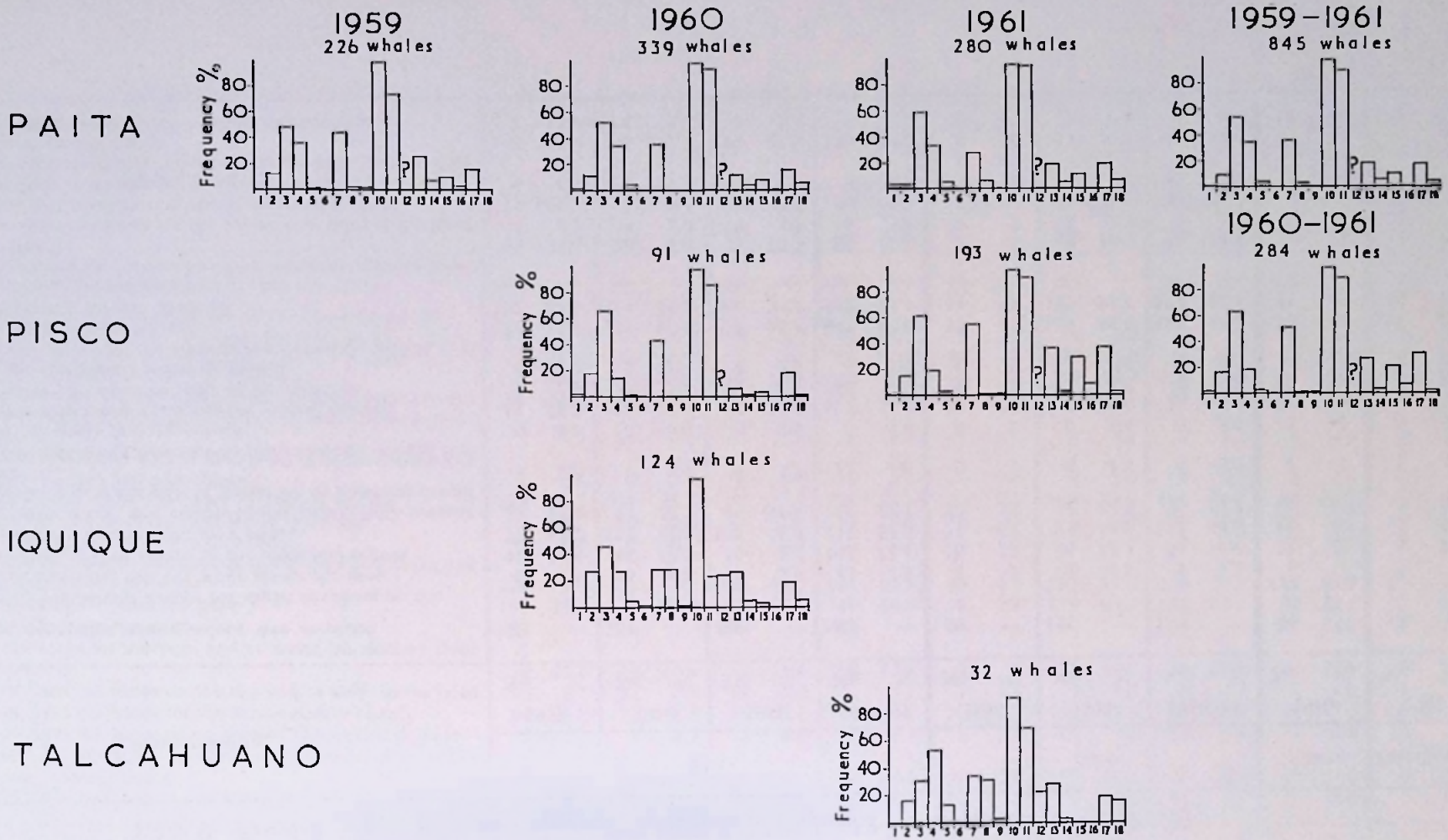


Fig. 5. Males. Colour variations of whales examined in Chile and Perú between 1959 and 1961. See Table 8 for definitions of the markings 1—18.

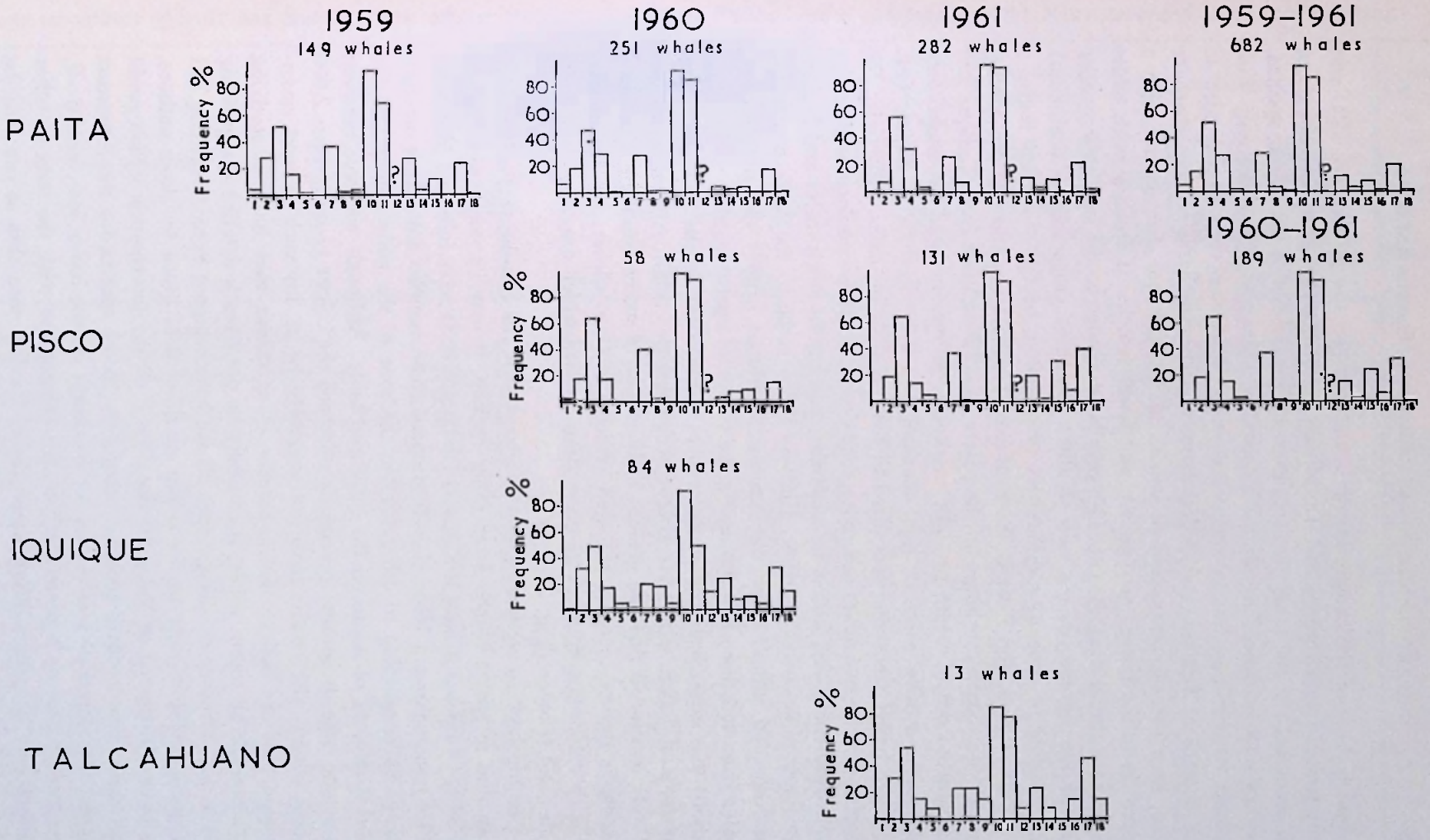


Fig. 6. Females. Colour variations of whales examined in Chile and Perú between 1959 and 1961.

5 and 6. One of the categories, dark markings on the palate (no. 12), was only looked for at Iquique and Talcahuano, so that nothing can be said about its occurrence at the other two localities. In Figs. 5 and 6 the colour spectra, as they may be called, are almost identical at Paita and Pisco, not only with respect to localities, but in successive years. They are very similar also to the spectra at Iquique and Talcahuano, and the small differences that are seen, as a greater proportion of whales at Iquique and Talcahuano with a white tip to the lower jaw (no. 8), and fewer females at Iquique with white markings around the gape (no. 11), may be attributed to the relatively smaller size of the samples at the two southern localities (especially Talcahuano) and possibly to subjective differences in recording by the observers there.

Table 10 and Fig. 7 show the combined results on colour for the Southeast Pacific. Dark markings on the palate (no. 12 sampled from Iquique and Talcahuano only), white or light markings on the forehead or snout (no. 13), and the rare white or light markings on the tail stock or flukes (no. 18), are found somewhat less often in females than in males. Otherwise the spectra for the two sexes are more remarkable for their similarities than for their differences, and it may be concluded that in this stock males and females are much alike in body colour. Clarke (1956) came to the same conclusion for his small sample from the Azores. Matthews (1938) did not separate males from females when discussing the colour of sperm whales, and Omura (1950) was inconclusive about differences in the colour of the two sexes from the coast of Japan, where his sample of females was small. Although Gudkov (1963) concluded that the general body colour of males from the Northeast Pacific is darker in tone than that of females (see below), the frequencies of such colour markings as he gives show spectra which are very similar for males and females (Fig. 7).

Coming now to compare colour variations in the Southeast Pacific stock with that in sperm whales from other regions, it may be noted that Omura (1950), Ohno & Fujino (1952), and Gudkov (1963) have followed Matthews (1938) in making a basic classification of their samples into three or four groups corresponding to differences in the tone of the body colour and the general amount of white on the head and body. Although we have between us at one time or another personally observed the colour of more than 2,000 sperm whales, the results have not suggested to us any such general classification, and we believe that, whatever value colour may have in studying variation in the sperm whale, it can only be got from a detailed categorizing of the actual colour markings, such as we have adopted here. Confining our attention therefore only to the colour marking data given by these authors, we have transferred to Table 10 and Fig. 7 all the information which could with confidence be fitted into our categories. In the spectra for the Southeast Pacific, the aggregate frequencies for markings on the lower jaw, nos. 6—9, have been added as a dotted outline, for comparison with the data of other authors who have not differentiated these. Having done this, it can only be

Table 10. *Colour variations of male and female sperm whales from the Southeast Pacific, and a comparison with those recorded from other oceans.*

| Colour marking | Southeast Pacific | | | | | | | | Antarctic and South Indian Ocean | Antarctic (♂♂ only) | North Pacific | | | | North Atlantic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males (1285) | | | Females (968) | | | Together (2253) | | Matthews (1938) on 70 whales | Ohno & Fujino (1952) on an unstated no. of whales | Omura (1950) on 231 whales | Gudkov (1963) on 200 whales | | | Clarke (1956) on 33 whales |
| | | | | | | | | | | | | ♂♂ (103) | ♀♀ (97) | Together (200) | |
| | No. | % | | No. | % | | No. | % | % | % | % | % | % | % | % |
| 1. Uniformly pigmented except for slight streaking on the body or (marking No. 10) white about the jaws | 19 | *1.5* | | 36 | *3.7* | | 55 | *2.4* | *9* | | | *10.7* | *9.3* | *10.0* | *3* |
| 2. Ventral white or grey splash in the umbilical region | 159 | *12.4* | | 170 | *17.6* | | 329 | *14.6* | *33* | *32* | *74.4* | *12.8* | *7.2* | *10.0* | *33* |
| 3. Ventro-lateral white or grey streaks | 698 | *54.3* | | 522 | *53.9* | | 1220 | *54.2* | | *85* | *87* | *58.3* | *55.7* | *57.0* | *39* |
| 4. Ventral white splash and ventro-lateral streaks both present | 390 | *30.4* | | 229 | *23.7* | | 619 | *27.5* | *24* | | | *13.6* | *25.8* | *19.5* | *15* |
| 5. Light flecking in the region of dorsal fin or posterior dorsal humps | 48 | *3.7* | | 23 | *2.4* | | 71 | *3.2* | *3* | | | | | | *9* |
| 6. Lower jaw half-white downwards from alveolar margin but margin of upper jaw pigmented | 3 | *0.2* | | 2 | *0.2* | | 5 | *0.2* | | | | | | | |
| 7. Lower jaw with white markings on ventral surface | 488 | *38.0* | *44.4* | 288 | *29.8* | *35.9* | 776 | *34.4* | *40.7* | | | *39.8* | *32.0* | *36.0* | *18* |
| 8. Tip of lower jaw white or with white markings | 69 | *5.4* | | 44 | *4.5* | | 113 | *5.0* | *17* | | | | | | |
| 9. Lower jaw completely white or whitish | 10 | *0.8* | | 14 | *1.4* | | 24 | *1.1* | | | | | | | |
| 10. Lower jaw half-white downwards from alveolar margin and white margin to upper jaw | 1249 | *97.2* | | 914 | *94.4* | | 2163 | *96.0* | *20* | | | | | | *48* |
| 11. White markings around the gape | 1053 | *81.9* | | 807 | *83.4* | | 1860 | *82.6* | | | | | | | |
| 12. Dark markings on the palate | (37) | *(23.7)** | | (13) | *(13.4)** | | (50) | *(19.8)** | *6* | | | | | | |
| 13. White markings on forehead and/or snout (as distinct from head whorl) | 267 | *20.8* | | 131 | *13.5* | | 398 | *17.7* | | | | | | | |
| 14. White or light markings on the top and/or sides of the head | 58 | *4.5* | | 33 | *3.4* | | 91 | *4.0* | | | | | | | |
| 15. White or light markings on the throat and/or chest | 144 | *11.2* | | 104 | *10.7* | | 248 | *11.0* | | | | | | | |
| 16. White or light markings on or around flippers or in axilla | 25 | *1.9* | | 25 | *2.6* | | 50 | *2.2* | | | | | | | |
| 17. White or light markings on or around genitals, anus and/or post-anal ventral hump | 256 | *19.9* | | 232 | *24.0* | | 488 | *21.7* | *7* | | | | | | |
| 18. White or light markings on tailstock and/or flukes | 53 | *4.1* | | 22 | *2.3* | | 75 | *3.3* | *7* | | | | | | *0* |

* These percentages are for the combined sample at Iquique and Talcahuano only, since dark markings on the palate were only looked for at these two localities in the Southeast Pacific.

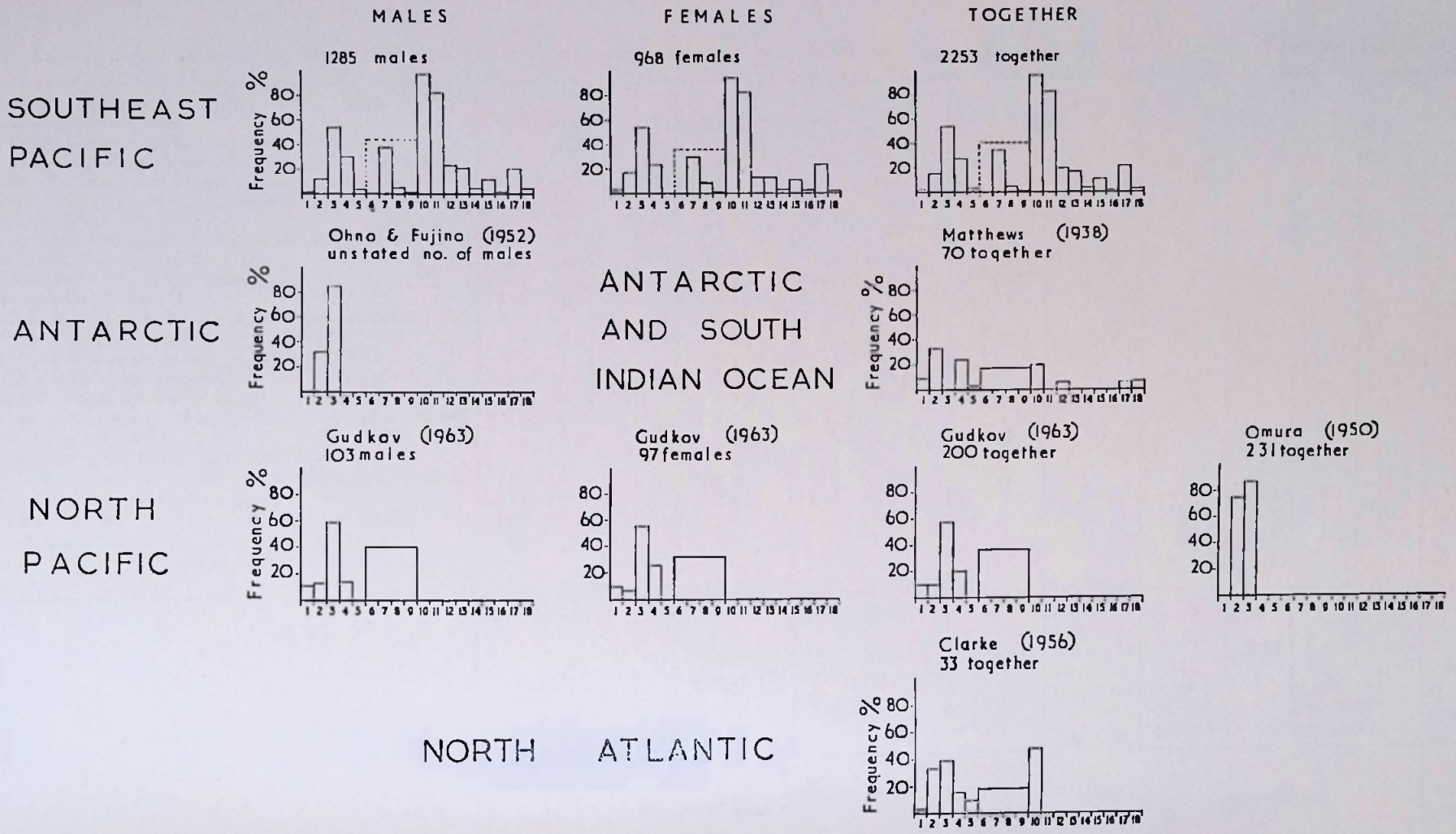


Fig. 7. Colour variations of male and female sperm whales from the Southeast Pacific, and a comparison with those recorded from other oceans.

said that Fig. 7 does show some differences in the samples from the other oceans, but their colour spectra are incomplete, the samples are mostly small, and we cannot be sure that in all cases we have correctly interpreted the markings as described, so that a more detailed discussion seems scarcely justified. However, Fig. 7 suggests that if the colour markings of fairly large samples of sperm whales in different oceans could be noted according to some classification like that adopted in the Southeast Pacific, results of significance might emerge.

Paliza (1964) has already described progressive pigmentation of the skin in 157 foetuses from the Southeast Pacific. She found that pigmentation started at about 0.50 m foetal length and was completed at about 3.50 m, the process starting in the middle dorsal region and advancing to the flanks, head, and tail. Her results confirm those of Matthews (1938, p. 119) from a small sample of foetuses from the South Indian Ocean. Clarke (1956, p. 245) examined five small foetuses from the North Atlantic and suggested that pigmentation could be completed at only 0.2 m foetal length, but these foetuses were preserved in formalin, and we have noticed that the rosy, unpigmented areas soon turn to shades of grey when foetuses are preserved.

*Head whorl*

Matthews (1938) drew attention to the presence in some sperm whales of a characteristic marking on the head, consisting of white and dark flecks and streaks spiralling from a centre on the lower part of the forehead. He called this the head whorl and figured it in a sepia sketch in his Plate V. The marking is to be distinguished from certain white streaks or splashes which sometimes occur on the forehead, and which comprise category no. 13 in the previous section on colour.

Matthews believed that Beale (1839) was referring to the head whorl when he said that old bull sperm whales generally had a portion of grey on the forehead, when they were called 'grey-headed'. Although no head whorl was noted in the foetuses available to Matthews, it occurred in two small males at Durban, at well as in larger whales from Durban and South Georgia, so he considered that the presence of a head whorl could not be taken as a sign of age. Paliza (1964) found that the head whorl did in fact occur among foetal sperm whales from Perú; the smallest foetus to possess the marking was a male of 2.90 m, and thereafter it was present in 58 % of all larger foetuses, being rather more common in males than in females.

Although Paliza's results strongly suggest that the head whorl is not associated with age, there remains the possibility that an existing whorl may increase in clarity and extent during postnatal life, for other authors (Omura, 1950; Ohno & Fujino, 1952) and ourselves have noted that the head whorl varies in its degree of development. Accordingly the frequencies of non-development (absence) of the head whorl, and of its degree of development when present, are tabulated for each metre of body length in Table 11,

Table 11. *Development of the head whorl and body length in whales examined at Paita and Pisco in Perú between 1959 and 1961.*

| Length m | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of whales | Not developed % | Slightly developed % | Moderately developed % | Well developed % | Totals | No. of whales | Not developed % | Slightly developed % | Moderately-developed % | Well developed % | Totals |
| 6.0 — 6.9 | *3* | | 33 | 67 | | 100 | *1* | 100 | | | | 100 |
| 7.0 — 7.9 | *8* | 25 | 38 | 25 | 12 | 100 | *12* | 58 | 33 | 8 | | 99 |
| 8.0 — 8.9 | *29* | 52 | 17 | 14 | 17 | 100 | *74* | 26 | 35 | 28 | 11 | 100 |
| 9.0 — 9.9 | *113* | 29.2 | 38.9 | 19.5 | 12.4 | 100.0 | *391* | 28.9 | 37.6 | 21.0 | 12.5 | 100.0 |
| 10.0 — 10.9 | *226* | 31.8 | 40.3 | 14.6 | 13.3 | 100.0 | *226* | 24.3 | 40.7 | 18.6 | 16.4 | 100.0 |
| 11.0 — 11.9 | *169* | 27.8 | 39.6 | 17.8 | 14.8 | 100.0 | *14* | 36 | 50 | | 14 | 100 |
| 12.0 — 12.9 | *116* | 26.7 | 31.9 | 21.6 | 19.8 | 100.0 | | | | | | |
| 13.0 — 13.9 | *111* | 24.3 | 36.0 | 18.9 | 20.7 | 99.9 | | | | | | |
| 14.0 — 14.9 | *87* | 17 | 32 | 23 | 28 | 100 | | | | | | |
| 15.0 — 15.9 | *82* | 17 | 28 | 12 | 43 | 100 | | | | | | |
| 16.0 — 16.9 | *40* | 10 | 18 | 27 | 45 | 100 | | | | | | |
| 17.0 — 17.9 | *3* | 33 | | 33 | 33 | 99 | | | | | | |

Table 12. *Development of the head whorl and condition of the vertebral column in whales examined at Paita and Pisco in Perú between 1959 and 1961.*

| Vertebral column: State of fusion of epiphyses to the centra | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of whales | Not developed % | Slightly developed % | Moderately developed % | Well developed % | Totals | No of whales | Not developed % | Slightly developed % | Moderately developed % | Well developed % | Totals |
| Unfused throughout column | *939* | 26.9 | 35.3 | 18.2 | 19.6 | 100.0 | *580* | 27.8 | 38.4 | 21.2 | 12.6 | 100.0 |
| Column partially fused | *23* | 22 | 4 | 39 | 35 | 100 | *51* | 18 | 49 | 14 | 20 | 101 |
| Fused throughout column — physical maturity | *17* | 12 | 47 | 12 | 29 | 100 | *81* | 35 | 31 | 18 | 16 | 100 |

and for three stages in the fusion of epiphyses to their centra along the vertebral column in Table 12. Estimates of the degree of development of the head whorl are subjective ones, so we have sought to minimize the error here by limiting the data in Tables 11 and 12 to those from Paita and Pisco where the same observers worked at both stations with large samples. Body length is no great use as a guide to age in female sperm whales, but there is nothing also in the stages towards physical maturity to suggest a correlation with the development of the head whorl in females. There is some indication of a correlation with body length in the case of males, but of scarcely any with the stages towards physical maturity in this sex. Perhaps the best that may be said is that the head whorl may or may not appear in the sperm whale, and that when it is present in large males it is likely to be moderately or well developed, possibly because of separation of the constituent flecks with increased size of the forehead. But from Tables 11 and 12 it seems that the marking is of no practical use as a guide to age.

There do exist, however, the grey-headed sperm whales mentioned by Beale, and these are old animals. Gudkov (1963) has pointed out that scar tissue in the sperm whale is unpigmented, so that whales which over the years acquire an accumulation of healed scars from the agent causing oval pits in the skin (most numerous around the head in sperm whales), and a confusion of scratches from the hooks and suckers of squid, go increasingly greyish, and then whitish around the head. They are the grey-heads. Clarke (1954, Plate XVI, Fig. 5) illustrates one of these from the Azores. Possibly in very old whales this whitening with scars may extend back over the body in time. There are two records, which seem reliable enough, of white sperm whales: one is from the coast of Perú, when the white whale taken by the *Anglo-Norse* pelagic expedition in August 1952 was photographed (Pelliet, 1952), and the other is from the whaling barque *Platina* on the Western Ground in the North Atlantic in August 1902 (Chippendale, 1953). One may only guess whether these were albinos or very old whales.

Since the head whorl appears to have little connection with age, and that in the male only, its variation may now be considered in the same way as other colour markings. In Table 13, a comparison of the frequencies of the degrees of development of the markings in males and females from places where the samples were large, that is from Paita and, to a lesser extent, from Pisco, shows very similar distributions of frequencies, except that in males the well-developed whorl is met somewhat more often than in females, which is to be expected from our findings on the head whorl and body length. Comparing now the results by localities, it is first to be remembered that, as noted above, the same observers worked at both Paita and Pisco, and between these places the similarity of the distributions is striking enough. The observers who worked at Iquique and Talcahuano were the same but they were different from those at Paita and Pisco, and their samples were much smaller. It is not surprising that there are differences. Even so, it is puzzling that

Table 13. *Development of the head whorl in whales examined in Chile and Perú between 1959 and 1961, and a comparison with results from other regions.*

| Head whorl | | Paita | Pisco | Iquique | Talcahuano | Chile and Perú Southeast Pacific | Antarctic (Ohno & Fujino, 1952) | North Pacific, Japan. (Omura, 1950) |
|---|---|---|---|---|---|---|---|---|
| | | | | | Males | | | |
| *Number of whales* | | *742* | *245* | *109* | *30* | *1126* | *(Unstated)* | *150* |
| Not developed | % | 26.1 | 27.3 | 56.9 | 57 | 30.2 | 22* | 13.3 |
| Slightly developed | % | 37.2 | 28.6 | 27.5 | 17 | 33.8 | 51* | 42.7 |
| Moderately developed | % | 18.1 | 19.2 | 1.8 | 13 | 16.6 | 19* | 37.3 |
| Well developed | % | 18.6 | 24.9 | 13.8 | 13 | 19.4 | 7* | 6.7 |
| Totals | % | 100.0 | 100.0 | 100.0 | 100 | 100.0 | 99 | 100.0 |
| | | | | | Females | | | |
| *Number of whales* | % | *574* | *144* | *77* | *13* | *808* | | *23* |
| Not developed | % | 25.6 | 36.8 | 87 | 69 | 34.1 | — | 13.1 |
| Slightly developed | % | 39.4 | 34.7 | 12 | 8 | 35.4 | — | 34.8 |
| Moderately developed | % | 21.3 | 16.7 | | | 18.1 | — | 39.1 |
| Well developed | % | 13.8 | 11.8 | 1 | 23 | 12.4 | — | 13.0 |
| Totals | % | 100.1 | 100.0 | 100 | 100 | 100.0 | — | 100.0 |

* These figures have been read from the histograms in Ohno & Fujino's Fig. 27

Table 14. *Development of the dorsal fin in whales examined in Chile and Perú between 1959 and 1961.*

| Dorsal Fin | | Paita ♂♂ | Paita ♀♀ | Pisco ♂♂ | Pisco ♀♀ | Iquique ♂♂ | Iquique ♀♀ | Talcahuano ♂♂ | Talcahuano ♀♀ | Chile and Perú ♂♂ | Chile and Perú ♀♀ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Number of whales* | | *350* | *284* | *281* | *187* | *123* | *84* | *33* | *12* | *787* | *567* |
| Slightly developed | % | 0.3 | 1.8 | 0.7 | 1.1 | | 1 | 6 | 8 | 0.6 | 1.6 |
| Moderately developed | % | 52.3 | 53.9 | 48.0 | 52.9 | 35.8 | 40 | 36 | 17 | 47.5 | 50.8 |
| Well developed | % | 47.4 | 44.3 | 51.2 | 46.0 | 64.2 | 58 | 58 | 75 | 51.8 | 47.6 |
| Totals | | 100.0 | 100.0 | 99.9 | 100.0 | 100.0 | 99 | 100 | 100 | 99.9 | 100.0 |

more than twice as many males and females at Iquique and Talcahuano had the head whorl absent as compared with those at Paita and Pisco: either this is a real difference, which is unlikely, or 'not developed' and 'slightly developed' have been differently interpreted in Chile and Perú.

Turning to other regions, Ohno & Fujino's sample of males from the Antarctic (1952) shows frequency distributions of the degrees of development of the head whorl not unlike those from males of the Southeast Pacific (Table 13). Matthews (1938) lumped together males and females examined

from the Antarctic and South Indian Ocean and noted that 25.6 % of these bore the head whorl, which is less than half the incidence in Ohno & Fujino's males (77 %), and in males and females together from the Southeast Pacific (67.8 % and from the North Pacific (86.8 % ; Omura, 1950). These last three results are not so different one from another, but Omura's results for the frequency distributions of the degrees of development of the head whorl in male and females from the North Pacific are quite different from those in the Southeast Pacific (Table 13).

It is difficult to say whether any of the observed differences in the head whorl, in whales from different oceans and localities, are real or not. The head whorl is such an intriguing configuration in itself that it was bound to command our attention in this study of variation in the sperm whale, but subjective differences in recording the character are probably so great that comparisons are of doubtful value where different observers have been involved.

*Dorsal fin*

As Clarke (1956, p. 246) has pointed out, the dorsal fin of the sperm whale varies a good deal in size and its limits are ill-defined. Measurements of the length and height can be approximate only, and observations vary between different observers, so that, as will be seen in the paper on body proportions now in preparation, comparison of these measurements in whales from different regions is really impracticable. Because the fin is always so broad transversely, the old whalemen often called it the 'hump', giving the impression that it scarcely merited the name of 'fin'. In an attempt to investigate this matter further, an observation on the degree of development of the dorsal fin was included in the routine examination of sperm whales in Chile and Perú. The results, of course, are from subjective impressions only and there are differences due to different observers in Chile and Perú, but for what they are worth they are given in Table 14. They do show that there is no difference between males and females in the development of the dorsal fin, and that the fin in nearly all sperm whales is well or moderately developed, the very low hump being rare.

On the dorsal fin of some sperm whales there is a rugose patch of skin which has recently been discussed by Kasuya & Ohsumi (1966). The material from Chile and Perú includes considerable data on this dorsal fin callus, but to treat it here would be somewhat inappropriate, and it will be discussed in a separate paper now in preparation.

*Posterior dorsal humps*

Along the mid-line between the dorsal fin and the flukes in the sperm whale there are a series of small elevations, called the posterior dorsal humps by Clarke (1956, p. 246) and collectively known to the old whalemen as the 'ridge' (Beale 1839, p. 24). They vary in number, but the largest, which is

Table 15. *Percentage frequencies of the numbers of posterior dorsal humps at each metre of body length in whales examined in Chile and Perú between 1959 and 1961.*

| Length m. | No. of whales | Number of humps | | | | | | | | | Totals % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| | | | | | Males | | | | | | |
| 6.0 — 6.9 | 3 | | | 33 | 33 | 33 | | | | | 99 |
| 7.0 — 7.9 | 11 | | 9 | | 36 | 46 | 9 | | | | 100 |
| 8.0 — 8.9 | 45 | 2 | | 9 | 24 | 38 | 20 | 7 | | | 100 |
| 9.0 — 9.9 | 141 | 5.0 | 2.8 | 7.8 | 21.3 | 31.9 | 26.2 | 3.5 | 1.4 | | 99.9 |
| 10.0 — 10.9 | 284 | 1.8 | 3.5 | 7.0 | 20.4 | 36.3 | 24.6 | 5.6 | 0.7 | | 99.9 |
| 11.0 — 11.9 | 207 | 2.9 | 1.9 | 7.7 | 19.8 | 35.3 | 24.6 | 7.7 | | | 99.9 |
| 12.0 — 12.9 | 130 | 0.8 | 3.8 | 6.2 | 19.2 | 28.5 | 26.9 | 13.1 | 1.5 | | 100.0 |
| 13.0 — 13.9 | 150 | 4.7 | 0.7 | 4.0 | 20.0 | 36.7 | 21.3 | 11.3 | 1.3 | | 100.0 |
| 14.0 — 14.9 | 108 | 2.8 | 1.9 | 1.9 | 18.5 | 36.1 | 27.8 | 8.3 | 1.9 | 0.9 | 100.1 |
| 15.0 — 15.9 | 116 | 1.7 | 2.6 | 5.2 | 10.3 | 32.8 | 33.6 | 11.2 | 0.9 | 1.7 | 100.0 |
| 16.0 — 16.9 | 46 | 2 | 4 | 9 | 7 | 33 | 35 | 7 | 2 | 2 | 101 |
| 17.0 — 17.9 | 3 | | | | | | 67 | 33 | | | 100 |
| Total | 1244 | | | | | | | | | | |
| | | | | | Females | | | | | | |
| 6.0 — 6.9 | 1 | | | 100 | | | | | | | 100 |
| 7.0 — 7.9 | 15 | 7 | | 13 | 60 | 13 | 7 | | | | 100 |
| 8.0 — 8.9 | 104 | 6.7 | 4.8 | 9.6 | 25.0 | 43.3 | 10.6 | | | | 100.0 |
| 9.0 — 9.9 | 494 | 6.3 | 4.0 | 8.3 | 26.7 | 34.4 | 16.6 | 3.0 | 0.4 | 0.2 | 99.9 |
| 10.0 — 10.9 | 304 | 5.9 | 4.3 | 9.9 | 23.0 | 36.5 | 15.8 | 3.3 | 1.3 | | 100.0 |
| 11.0 — 11.9 | 23 | | 13 | 30 | 17 | 13 | 13 | 13 | | | 99 |
| Total | 941 | | | | | | | | | | |
| Grand Total | 2185 | | | | | | | | | | |

not an abrupt prominence like the others but a smooth rising of the tailstock just in front of the flukes, is always present. They are illustrated by Clarke (1956, Plate I, Fig. 5).

Paliza (1964) found that the posterior dorsal humps began to appear at 0.15 m body length in the 157 foetuses she examined in Perú: the last of the series appeared first, and thereafter the others appeared almost simultaneously. This is good evidence that the number of humps does not increase with age, but we have tested this further in the data from the postnatal whales examined in Chile and Perú, by comparing in Table 15 the frequencies of the number of humps at each metre of body length. The table shows no correlation.

Coming then to consider the number of humps as a variable character, it is seen from Table 16 that in whales from Chile and Perú the number may range from one to nine in both males and females. Very rarely there may perhaps be more, because we have a note of one female (serial no. Pa 130) which had 'many shallow posterior dorsal humps'. Table 16 and Fig. 18 compare the frequencies of the numbers of humps in whales from the four localities in Chile and Perú. There seem to be no differences which cannot be explained by the different sizes of the samples available, and for the South-

Table 16. *Frequencies of the numbers of posterior dorsal humps in whales examined in Chile and Perú between 1959 and 1961.*

| No. of humps | Males | | | | | | | | | | Females | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Paita | | Pisco | | Iquique | | Talcahuano | | Chile and Perú | | Paita | | Pisco | | Iquique | | Talcahuano | | Chile and Perú | |
| | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % | No. | % |
| 1 | 17 | *2.1* | 13 | *4.6* | | | 3 | *9* | 33 | *2.7* | 42 | *6.4* | 14 | *7.4* | 1 | *1* | | | 57 | *6.1* |
| 2 | 19 | *2.4* | 10 | *3.5* | 3 | *2.4* | | | 32 | *2.6* | 23 | *3.5* | 12 | *6.4* | 7 | *8* | | | 42 | *4.5* |
| 3 | 48 | *5.9* | 23 | *8.2* | 4 | *3.3* | 3 | *9* | 78 | *6.3* | 60 | *9.1* | 23 | *12.2* | 6 | *7* | 2 | *17* | 91 | *9.7* |
| 4 | 150 | *18.6* | 56 | *19.9* | 20 | *16.3* | 9 | *28* | 235 | *18.9* | 153 | *23.3* | 61 | *32.4* | 24 | *29* | 3 | *25* | 241 | *25.6* |
| 5 | 252 | *31.2* | 112 | *39.7* | 55 | *44.7* | 9 | *28* | 428 | *34.4* | 245 | *37.3* | 59 | *31.4* | 24 | *29* | 3 | *25* | 331 | *35.2* |
| 6 | 230 | *28.5* | 51 | *18.1* | 34 | *27.6* | 7 | *22* | 322 | *25.9* | 107 | *16.3* | 16 | *8.5* | 18 | *21* | 3 | *25* | 144 | *15.3* |
| 7 | 77 | *9.5* | 16 | *5.7* | 6 | *4.9* | 1 | *3* | 100 | *8.0* | 20 | *3.0* | 3 | *1.6* | 4 | *5* | 1 | *8* | 28 | *3.0* |
| 8 | 11 | *1.4* | 1 | *0.4* | | | | | 12 | *1.0* | 6 | *0.9* | | | | | | | 6 | *0.6* |
| 9 | 3 | *0.4* | | | 1 | *0.8* | | | 4 | *0.3* | 1 | *0.2* | | | | | | | 1 | *0.1* |
| Totals | 807 | *100.0* | 282 | *100.1* | 123 | *100.0* | 32 | *99* | 1244 | *100.1* | 657 | *100.0* | 188 | *99.9* | 84 | *99* | 12 | *100* | 941 | *100.1* |

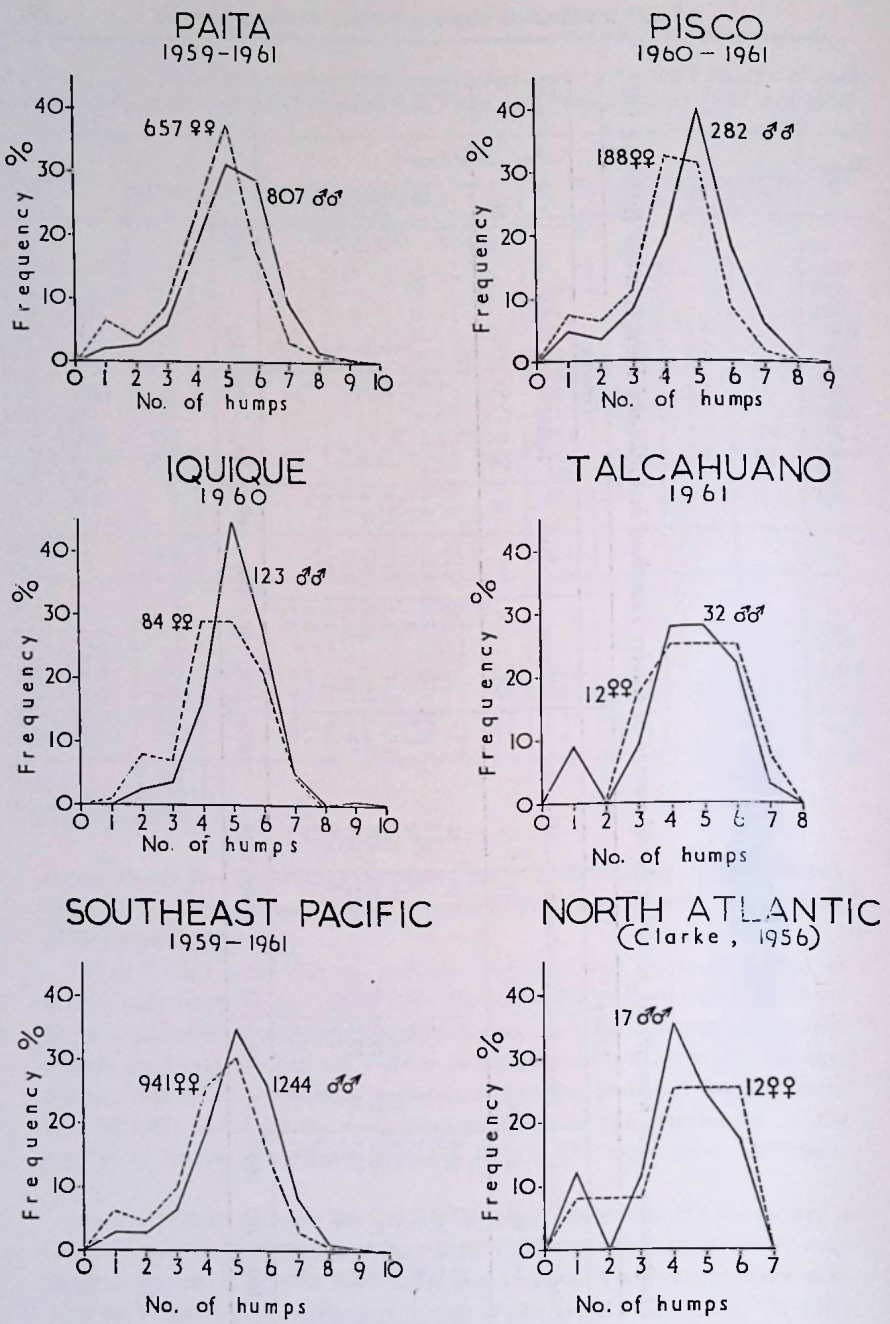


Fig. 8. Frequencies of the numbers of posterior dorsal humps in whales examined in Chile and Perú between 1959 and 1961. Results from the North Atlantic (Clarke, 1956) are also shown.

east Pacific as a whole there is a fairly symmetrical normal frequency distribution around five humps for both males and females. Paliza's Table 7 for foetuses from Perú also showed a mode at five humps for both sexes.

In other oceans, Clarke's results from the North Atlantic (Fig. 8) suggest that four was the mode for the number of humps in males, and that four, five or six might be equally common in females, but his sample was small, like that for Talcahuano which his results do in fact resemble. Elsewhere there are only general statements: Matthews (1938, p. 120) said that in whales examined from the Antarctic and South Indian Oceans, the humps were 'usually four or five in number', whilst Ivanova (1955) noticed that the usual number in her sample from the Northeast Pacific was three or four, although it is clear from Ivanova's text that she was not counting the last hump, that smooth rising in front of the flukes. A useful comparison here would require more information from whales from other oceans, but what little there is suggests that whales elsewhere are not likely to differ from those of the Southeast Pacific in the number of posterior dorsal humps.

*Anterior dorsal humps*

It is interesting to note that in nine out or 1,244 male sperm whales in Chile and Perú (0.7 %), humps ranging from one to six in number were recorded *anterior* to the dorsal fin. They were recorded from none of the 941 females. These anterior dorsal humps have not previously been recorded from the sperm whale, and they may be regarded as a rare variation occurring only in the male.

*Throat grooves*

The longitudinal grooves in the throat region of the sperm whale (illustrated by Clarke 1956, Plate I, Fig. 2) exhibit much variation in kind and number and arrangement. There are sketches and notes of these from 1,274 males and 957 females in the data from Chile and Perú.

*Deep and shallow grooves.* The grooves may be distinguished as deep grooves, with depths as much as 7 cm, or as shallow grooves around one centimetre in depth. The deep grooves range in length from about 10 cm to as much as 57 cm (in whale Pa 16, ♂), and the shallow grooves from a few centimetres to nearly a metre. In any whale the grooves may all be deep ones, or all shallow, or both deep and shallow ones may be present (Fig. 11), or rarely they may be altogether absent. The frequencies of occurrence of these kinds of grooves are shown in Table 17. Results from Paita and Pisco are very similar. They are not much different from the smaller sample at Iquique, but both here and at Talcahuano the different observers may have interpreted 'deep' and 'shallow' a little differently. All four localities show differences between males and females: looking at the aggregate figures, it is seen that

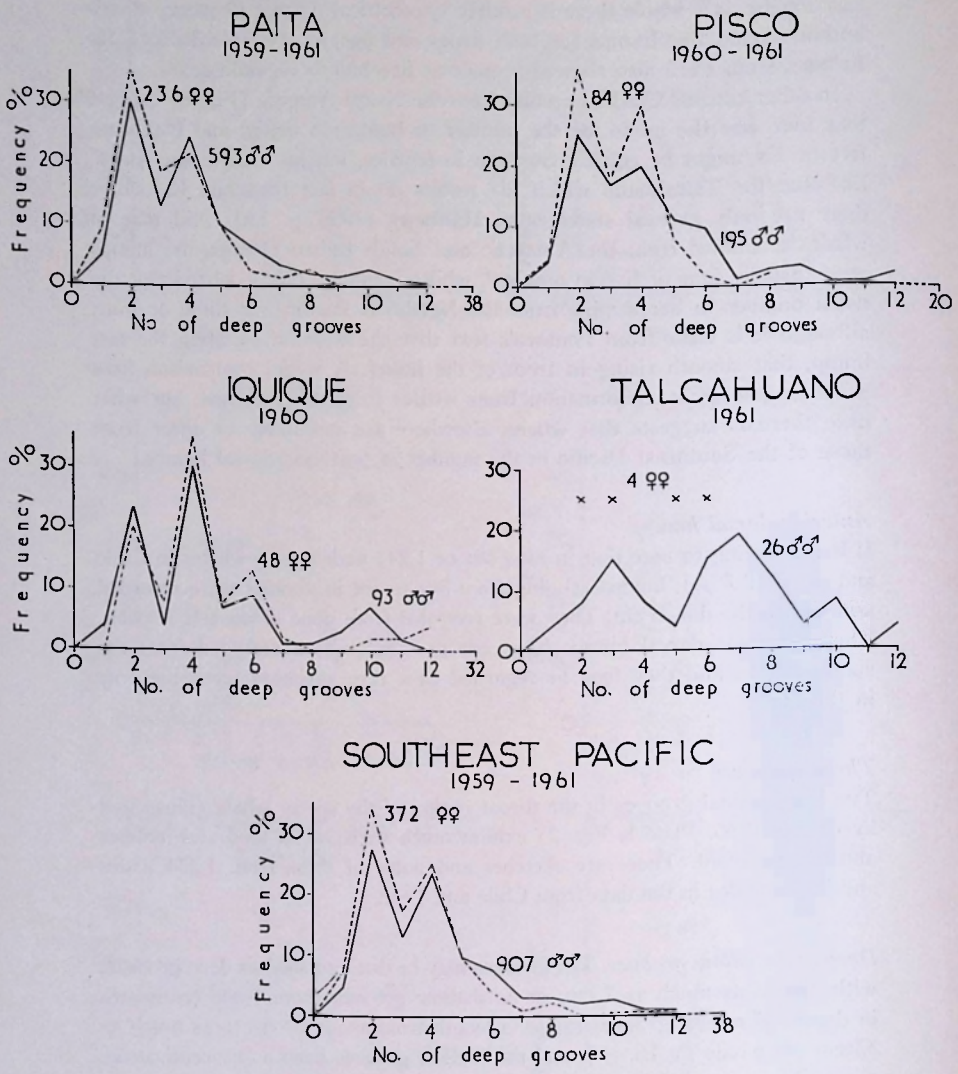


Fig. 9. Frequencies of the numbers of deep throat grooves in whales examined in Chile and Perú between 1959 and 1961.

in males there are twice as many with both deep and shallow grooves as there are with shallow grooves only, whereas the reverse holds for females; also there are noticeably more females (3.4 %) than males (0.9 %) in which throat grooves are quite absent.

Table 17. *Frequencies of the kinds of throat grooves in whales examined in Chile and Perú between 1959 and 1961.*

| Throat grooves | | Paita ♂♂ | Paita ♀♀ | Pisco ♂♂ | Pisco ♀♀ | Iquique ♂♂ | Iquique ♀♀ | Talcahuano ♂♂ | Talcahuano ♀♀ | Chile and Perú ♂♂ | Chile and Perú ♀♀ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Number of whales* | | *825* | *635* | *281* | *189* | *121* | *81* | *30* | *13* | *1257* | *918* |
| Grooves absent | % | 0.8 | 3.8 | 1.1 | 3.2 | 0.8 | 1 | | | 0.9 | 3.4 |
| With deep grooves only | % | 15.9 | 11.5 | 16.7 | 18.0 | 27.3 | 30 | 10 | | 17.0 | 14.3 |
| With shallow grooves only | % | 27.4 | 58.6 | 29.5 | 52.4 | 22.3 | 42 | 17 | 69 | 27.1 | 56.0 |
| With both deep and shallow grooves | % | 55.9 | 26.1 | 52.7 | 26.4 | 49.6 | 27 | 73 | 31 | 55.0 | 26.4 |
| Totals | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100 | 100 | 100 | 100.0 | 100.1 |

Paliza (1964) was able to distinguish shallow from deep grooves in the 157 foetuses she examined from Perú. No throat grooves were found in foetuses smaller than 0.7 m, an observation supported by the records of some earlier authors, although there must be some variation in the foetal age at which the grooves first appear since Clarke (1956, p. 247) recorded them from a foetus of 0.24 m in the North Atlantic. Paliza found that all foetuses larger than 3.0 m in her sample bore throat grooves. Her Table 3 shows that shallow grooves are the first to appear, no foetus smaller than 2.5 m having deep grooves, whilst among foetuses larger than 3.5 m there were three which showed both deep and shallow grooves.

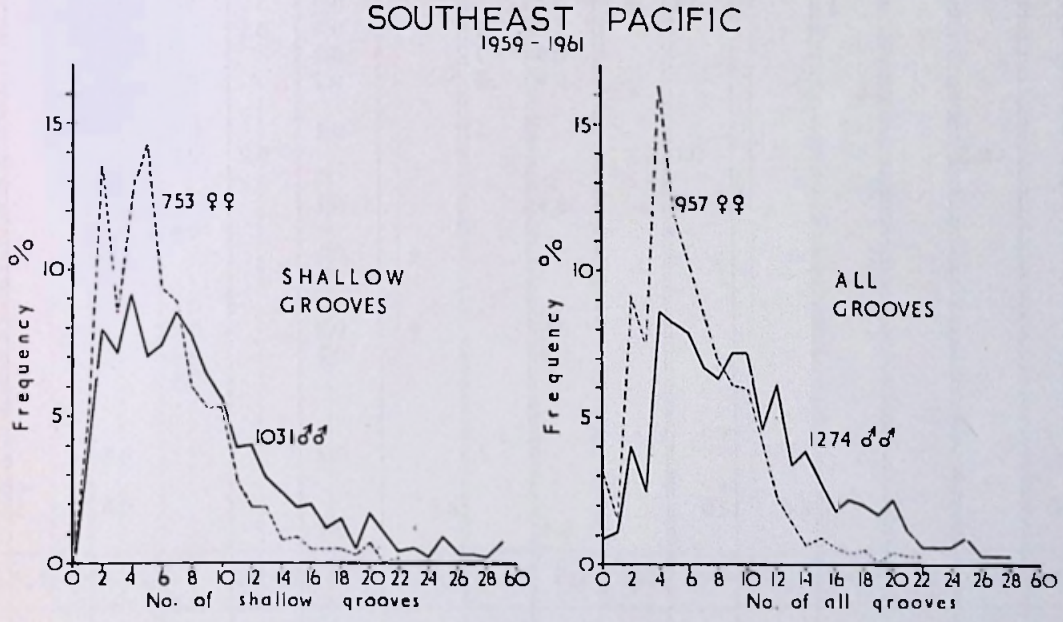


Fig. 10. Frequencies of the numbers of shallow throat grooves and of all throat grooves in whales examined in Chile and Perú between 1959 and 1961.

Table 18. *Males. Percentage frequencies of the numbers of throat grooves in whales examined in Chile and Perú between 1959 and 1961.*

| No. of grooves | Deep grooves | | | | | Shallow grooves | | | | | Total number of grooves | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Paita (593) | Pisco (195) | Iquique (93) | Talcahuano (26) | Chile and Perú (907) | Paita (686) | Pisco (232) | Iquique (87) | Talcahuano (26) | Chile and Perú (1031) | Paita (836) | Pisco (284) | Iquique (123) | Talcahuano (31) | Chile and Perú (1274) |
| 0 | | | | | | | | | | | 0.9 | 1.0 | 0.8 | | 0.9 |
| 1 | 4.9 | 4.1 | 4 | 4 | 4.6 | 4.1 | 0.9 | 6 | 8 | 3.6 | 1.3 | 0.7 | 0.8 | | 1.1 |
| 2 | 29.5 | 25.1 | 23 | 8 | 27.2 | 9.2 | 5.2 | 7 | 4 | 7.9 | 4.2 | 2.8 | 5.7 | 3 | 4.0 |
| 3 | 13.0 | 16.9 | 4 | 15 | 13.0 | 7.7 | 6.9 | 5 | | 7.1 | 2.9 | 2.1 | 0.8 | 3 | 2.5 |
| 4 | 24.3 | 20.0 | 30 | 8 | 23.5 | 8.7 | 11.6 | 7 | 4 | 9.1 | 9.7 | 7.0 | 7.3 | | 8.6 |
| 5 | 9.8 | 11.3 | 7 | 4 | 9.6 | 7.6 | 6.0 | 5 | 8 | 7.0 | 9.8 | 4.6 | 7.3 | | 8.2 |
| 6 | 6.6 | 9.7 | 9 | 15 | 7.7 | 8.0 | 5.2 | 8 | 8 | 7.4 | 7.9 | 8.8 | 7.3 | 3 | 7.9 |
| 7 | 3.4 | 1.0 | 1 | 19 | 3.1 | 9.2 | 7.8 | 7 | 4 | 8.5 | 7.1 | 6.0 | 4.9 | 10 | 6.7 |
| 8 | 2.0 | 2.6 | 7 | 12 | 2.9 | 8.0 | 7.3 | 8 | | 7.7 | 6.1 | 6.3 | 6.5 | 10 | 6.3 |
| 9 | 1.5 | 3.1 | 3 | 4 | 2.1 | 7.3 | 5.2 | 2 | 8 | 6.4 | 7.8 | 6.7 | 4.9 | 7 | 7.2 |
| 10 | 2.5 | 0.5 | 7 | 8 | 2.6 | 4.5 | 5.6 | 14 | 8 | 5.6 | 6.7 | 6.3 | 13.8 | 3 | 7.2 |
| 11 | 1.0 | 0.5 | 2 | | 1.0 | 4.1 | 4.7 | | 4 | 3.9 | 4.8 | 4.6 | 3.3 | 7 | 4.6 |
| 12 | 0.3 | 2.1 | | 4 | 0.8 | 2.8 | 6.5 | 7 | 4 | 4.0 | 4.9 | 10.6 | 5.7 | | 6.1 |
| 13 | 0.3 | 2.1 | | | 0.7 | 3.5 | 2.2 | 1 | | 2.9 | 3.6 | 3.9 | 1.6 | | 3.4 |
| 14 | 0.5 | | 1 | | 0.4 | 2.0 | 4.3 | 1 | | 2.4 | 3.6 | 4.2 | 4.9 | 7 | 3.9 |
| 15 | | | | | | 2.5 | 0.9 | 1 | | 1.9 | 3.3 | 1.0 | 1.6 | 7 | 2.8 |
| 16 | | | | | | 1.9 | 2.6 | 1 | 4 | 2.0 | 2.0 | 1.8 | 0.8 | | 1.8 |
| 17 | | 0.5 | | | 0.1 | 1.3 | 1.3 | | | 1.2 | 2.3 | 3.2 | | | 2.2 |
| 18 | | | 1 | | 0.1 | 1.6 | 0.9 | 2 | 4 | 1.5 | 2.0 | 1.8 | 3.3 | | 2.0 |
| 19 | 0.2 | | | | 0.1 | 0.4 | 0.9 | | | 0.5 | 1.7 | 1.0 | | 3 | 1.4 |
| 20 | | 0.5 | 1 | | 0.2 | 1.0 | 1.7 | 5 | 11 | 1.7 | 1.7 | 2.8 | 4.1 | 3 | 2.2 |
| 21 | | | | | | 1.0 | 0.4 | | 8 | 1.0 | 1.1 | 1.0 | | 7 | 1.1 |
| 22 | | | | | | 0.6 | | | | 0.4 | 0.6 | 0.4 | 1.6 | | 0.6 |
| 23 | | | | | | 0.7 | | | | 0.5 | 0.6 | 0.7 | | 3 | 0.6 |
| 24 | | | | | | 0.2 | | | 4 | 0.2 | 0.5 | 0.4 | 1.6 | 3 | 0.6 |
| 25 | | | | | | 0.7 | 1.7 | | | 0.9 | 0.9 | 1.0 | 0.8 | | 0.9 |
| 26 | | | | | | 0.2 | | 2 | | 0.3 | 0.4 | | | 3 | 0.3 |
| 27 | | | | | | | 0.9 | 1 | | 0.3 | 0.4 | 0.4 | | | 0.3 |
| 28 | | | | | | 0.2 | 0.4 | | | 0.2 | | 0.7 | 0.8 | 3 | 0.3 |
| 29 | | | | | | 0.3 | 1.3 | 2 | | 0.7 | 0.1 | 0.7 | | 7 | 0.4 |
| 30 | | | | | | 0.2 | 1.3 | | | 0.4 | 0.4 | 1.4 | 1.6 | | 0.7 |
| 31 | | | | | | 0.3 | 0.4 | | | 0.3 | 0.4 | | 0.8 | | 0.3 |
| 32 | | | 1 | | 0.1 | 0.2 | 0.4 | | | 0.2 | | 0.7 | 0.8 | | 0.2 |
| 33 | | | | | | | 1.3 | 1 | | 0.4 | 0.1 | 1.0 | 1.6 | | 0.5 |
| 34 | | | | | | | 0.9 | 1 | | 0.3 | | | 0.8 | | 0.1 |
| 35 | | | | | | | 0.4 | 2 | | 0.3 | | 0.7 | 0.8 | | 0.2 |
| 36 | | | | | | | | | | | | | | | |
| 37 | | | | | | | | 1 | | 0.1 | | 0.4 | | | 0.1 |
| 38 | 0.2 | | | | 0.1 | | | | | | 0.2 | 0.7 | | | 0.3 |
| 39 | | | | | | | | | | | | | 0.8 | | 0.1 |
| 40 | | | | | | | 0.4 | | | 0.1 | | | | | |
| 41 | | | | | | | | | | | | 0.4 | 0.8 | | 0.2 |
| 42 | | | | | | | | | 4 | 0.1 | | | | | |
| 43 | | | | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | | | | |
| 45 | | | | | | | 0.9 | | 4 | 0.3 | | 0.4 | | | 0.1 |
| 46 | | | | | | | 0.4 | | | 0.1 | | 0.4 | | | 0.1 |
| 47 | | | | | | | | | | | | 0.4 | | 3 | 0.2 |
| 48 | | | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | | | |
| 50 | | | | | | | | 2 | | 0.2 | | | 0.8 | | 0.1 |
| 51 | | | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | 0.8 | | 0.1 |
| 53 | | | | | | | 0.4 | | | 0.1 | | | | | |
| 54 | | | | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | | | 3 | 0.1 |
| 56 | | | | | | | | | | | | 0.4 | | | 0.1 |
| – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 60 | | | | | | | | | 4 | 0.1 | | | | 3 | 0.1 |
| Anastomosed | | | | | | 0.2 | 0.9 | | | 0.3 | 0.1 | 0.7 | | | 0.2 |
| Totals % | 100.0 | 100.0 | 101 | 101 | 99.9 | 100.2 | 100.1 | 99 | 103 | 100.1 | 100.1 | 100.1 | 99.8 | 101 | 99.9 |

Table 19. *Females. Percentage frequencies of the numbers of throat grooves in whales examined in Chile and Perú between 1959 and 1961.*

| No. of grooves | Deep grooves | | | | | Shallow grooves | | | | | Total number of grooves | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Paita (*236*) | Pisco (*84*) | Iquique (*48*) | Talcahuano (*4*) | Chile and Perú (*372*) | Paita (*535*) | Pisco (*149*) | Iquique (*56*) | Talcahuano (*13*) | Chile and Perú (*753*) | Paita (*671*) | Pisco (*189*) | Iquique (*84*) | Talcahuano (*13*) | Chile and Perú (*957*) |
| 0 | | | | | | | | | | | 3.6 | 3.2 | 1 | | 3.2 |
| 1 | 8.1 | 4 | | | 5.9 | 5.6 | 2.7 | 5 | | 4.9 | 1.9 | 1.1 | | | 1.6 |
| 2 | 35.2 | 36 | 25 | 25 | 33.9 | 12.5 | 18.1 | 14 | | 13.5 | 8.6 | 10.6 | 11 | | 9.1 |
| 3 | 18.6 | 18 | 8 | 25 | 17.2 | 8.0 | 8.7 | 13 | 8 | 8.5 | 7.7 | 9.0 | 4 | | 7.5 |
| 4 | 21.6 | 30 | 35 | | 25.0 | 12.3 | 12.1 | 16 | 8 | 12.5 | 15.4 | 15.9 | 26 | 8 | 16.3 |
| 5 | 9.7 | 8 | 8 | 25 | 9.4 | 14.2 | 16.8 | 7 | 23 | 14.3 | 11.8 | 14.3 | 8 | 15 | 12.0 |
| 6 | 2.5 | 2 | 13 | 25 | 4.0 | 9.5 | 8.7 | 13 | | 9.4 | 10.3 | 9.0 | 14 | | 10.2 |
| 7 | 1.3 | | 2 | | 1.1 | 9.7 | 6.7 | 7 | 8 | 8.9 | 8.9 | 7.4 | 6 | 8 | 8.4 |
| 8 | 2.5 | 2 | | | 2.2 | 6.5 | 5.4 | 2 | 8 | 6.0 | 6.7 | 7.9 | 6 | 15 | 7.0 |
| 9 | | | | | | 5.8 | 4.0 | 5 | | 5.3 | 6.4 | 5.3 | 6 | | 6.1 |
| 10 | | | 2 | | 0.3 | 4.7 | 6.7 | 5 | 15 | 5.3 | 5.7 | 6.9 | 5 | 15 | 6.0 |
| 11 | | | 2 | | 0.3 | 2.8 | 2.0 | 4 | 8 | 2.8 | 4.5 | 2.6 | 4 | 15 | 4.2 |
| 12 | 0.4 | | 4 | | 0.8 | 1.5 | 2.0 | 4 | 8 | 1.9 | 2.2 | 2.1 | 2 | 8 | 2.3 |
| 13 | | | | | | 2.2 | 0.7 | 2 | | 1.9 | 1.5 | 0.5 | 2 | | 1.4 |
| 14 | | | | | | 0.6 | 1.3 | 2 | | 0.8 | 0.9 | | 1 | | 0.7 |
| 15 | | | | | | 0.6 | 2.0 | | 8 | 0.9 | 0.9 | 1.1 | | 8 | 0.9 |
| 16 | | | | | | 0.6 | 0.7 | | | 0.5 | 0.4 | 1.6 | | | 0.6 |
| 17 | | | | | | 0.8 | | | | 0.5 | 0.6 | | | | 0.4 |
| 18 | | | | | | 0.8 | | | | 0.5 | 0.6 | 0.5 | | | 0.5 |
| 19 | | | | | | | 0.7 | 2 | | 0.3 | 0.2 | | | | 0.1 |
| 20 | | | | | | 0.8 | | | 8 | 0.7 | 0.6 | | | | 0.4 |
| 21 | | | | | | | | | | | 0.2 | 0.5 | 1 | | 0.3 |
| 22 | | | | | | 0.2 | | | | 0.1 | 0.2 | | 2 | | 0.3 |
| 23 | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | 8 | 0.1 |
| 26 | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | |
| 36 | | | | | | | | | | | | | | | |
| 37 | | | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | | | | |
| 40 | | | | | | | 0.7 | | | 0.1 | | | | | |
| 41 | | | | | | | | | | | | 0.5 | | | 0.1 |
| Anastomosed | | | | | | 0.4 | | | | 0.3 | 0.3 | | | | 0.2 |
| Totals % | 99.9 | 100 | 99 | 100 | 100.1 | 100.1 | 100.0 | 101 | 102 | 99.9 | 100.1 | 100.0 | 99 | 100 | 99.9 |

*Frequency distribution.* In Table 18 and 19 the frequencies of the numbers of deep and shallow grooves are counted for each kind irrespective of whether or not the other kind was present, whilst the third category gives the frequencies of straight counts for all grooves, and only here are recorded the few whales where grooves were entirely absent. It is seen that the range in numbers of grooves is greater in males than in females. As many as 38 deep and 60 shallow grooves have been recorded in males, whereas the maxima for females are 12 and 40 respectively. (Rarely the shallow grooves in both sexes are anastomosed and therefore impossible to count.) However, the frequency distributions of the numbers of grooves, best seen in Figs. 9 and 10, are for the majority of animals very similar in both sexes. Deep grooves show well-defined modes at two and four grooves in males and females (Fig. 9). There is more dispersion in the frequencies of the shallow grooves, but the peaks at two and four grooves are sufficiently strong to reappear for both sexes in the counts of all grooves together (Fig. 10). Frequencies of the deep grooves are shown by localities in Fig. 9, and the graphs are similar at Paita, Pisco, and Iquique, although at Talcahuano the data are scarcely sufficient for comment.

As is to be expected, Paliza also found that two and four grooves were the most common numbers in both sexes of the foetuses from Perú.

*Patterns of symmetry and asymmetry.* Table 20 attempts to analyse variation in the arrangement of the throat grooves as frequencies of the patterns of symmetry and asymmetry which may be discerned. The various patterns defined in Table 20 are illustrated in Fig. 11 from examples sketched on the whaling platform, so that they call for no further description. It is seen in Table 20 that, where the patterns are based on the arrangement of deep grooves, 59.7 % of all males and of all females showed patterns of symmetry. At each locality also this proportion of the symmetrical to the asymmetrical group of patterns is very similar in males and females, even at Talcahuano where — either because of the small sample or because of some real difference — the proportion found elsewhere is inverted. Further, within the symmetrical group itself the distributions of the frequencies of medium and bilateral symmetry are alike for males and females. However, within the asymmetrical group the frequencies of the various patterns show less similarity between males and females, the throat grooves of the latter offering fewer examples of median asymmetry. In those whales which had only shallow throat grooves, there were fewer with symmetrical patterns, and the frequencies of these are alike in males and females at Paita, Iquique, and Talcahuano, but not, surprisingly enough, at Pisco. In fact, patterns where all the grooves were shallow show a good deal of variation, whereas in the patterns based on deep grooves, by far the largest group is that of bilateral symmetry of two or four grooves. This group accounts for the modes at two and four grooves which characterize the frequency distributions. In the small sample

Table 20. *Percentage frequencies of patterns of symmetry and asymmetry in the throat grooves of whales examined in Chile and Perú between 1959 and 1961.*

| Patterns of symmetry and asymmetry | | | Males | | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Paita (827) | Pisco (279) | Iquique (119) | Talca-huano (29) | Chile and Perú (1254) | Paita (608) | Pisco (183) | Iquique (80) | Talca-huano (13) | Chile and Perú (884) |
| *Based on the deep grooves* | | | | | | | | | | | | |
| Symmetry | Median | with one groove | 0.3 | 1.0 | 2 | | 0.7 | 0.4 | 1 | | | 0.5 |
| | | with more than one | 7.4 \| 58.9 | 10.2 \| 60.7 | 16 \| 71 | 13 \| | 9.0 \| 59.7 | 3.4 \| 54.0 | 10 \| 73 | 18 \| | | 6.7 \| 59.7 |
| | Bilateral | with two grooves | 28.6 \| | 25.0 \| | 23 \| | \| 26 | 26.5 \| | 34.6 \| | 35 \| | 26 \| 68 | 25 | 33.3 \| |
| | | with more than two | 22.6 | 24.5 | 30 | 13 | 23.5 | 15.6 | 27 | 24 \| | | 19.2 |
| Asymmetry | Unilateral | with one groove | 4.7 \| | 3.1 \| | 3 \| | 4 \| | 4.2 \| | 7.2 \| | 2 \| | | | 5.1 \| |
| | | with more than one | 1.0 \| | 1.0 \| | 1 \| | 13 \| | 1.3 \| | 2.5 \| | 1 \| | | | 1.9 \| |
| | Median | | 10.5 \| 41.0 | 12.2 \| 39.2 | 11 \| 29 | 25 \| 76 | 11.3 \| 40.3 | 5.5 \| 46.0 | 2 \| 26 | 8 \| | 25 \| | 5.3 \| 40.3 |
| | Bilateral | with three grooves | 10.1 \| | 11.7 \| | 1 \| | 13 \| | 9.6 \| | 16.5 \| | 13 \| | 8 \| 32 | 25 \| 75 | 14.7 \| |
| | | with more than three | 14.7 | 11.2 | 13 | 21 | 13.9 | 14.3 | 8 | 16 \| | 25 \| | 13.3 |
| Totals % | | | 99.9 | 99.9 | 100 | 102 | 100.0 | 100.0 | 99 | 100 | 100 | 100.0 |
| *Where all grooves were shallow* | | | | | | | | | | | | |
| Symmetry | Median | | 17.4 \| 35.7 | 34 \| 68 | 40 \| 68 | 20 | 23.0 \| 45.4 | 11.3 \| 33.7 | 10 \| 35 | 17 \| 67 | 11 \| 22 | 11.4 \| 35.8 |
| | Bilateral | | 18.3 \| | 34 \| | 28 \| | | 22.4 \| | 22.4 \| | 25 \| | 50 \| | 11 \| | 24.4 \| |
| Asymmetry | Unilateral | | 3.8 \| | 1 \| | | | 2.9 \| | 3.5 \| | 1 \| | | | 2.7 \| |
| | Median | | 21.7 \| 63.4 | 17 \| 32 | 20 \| 32 | 60 \| 80 | 21.0 \| 54.1 | 22.4 \| 66.1 | 18 \| 65 | 17 \| 34 | | 20.8 \| 64.0 |
| | Bilateral | | 37.9 \| | 14 \| | 12 \| | 20 \| | 30.2 \| | 40.2 \| | 46 \| | 17 \| | 78 | 40.5 \| |
| Anastomosed grooves | | | 0.9 | | | | 0.6 | 0.3 | | | | 0.2 |
| Totals % | | | 100.0 | 100 | 100 | 100 | 100.1 | 100.1 | 100 | 101 | 100 | 100.0 |

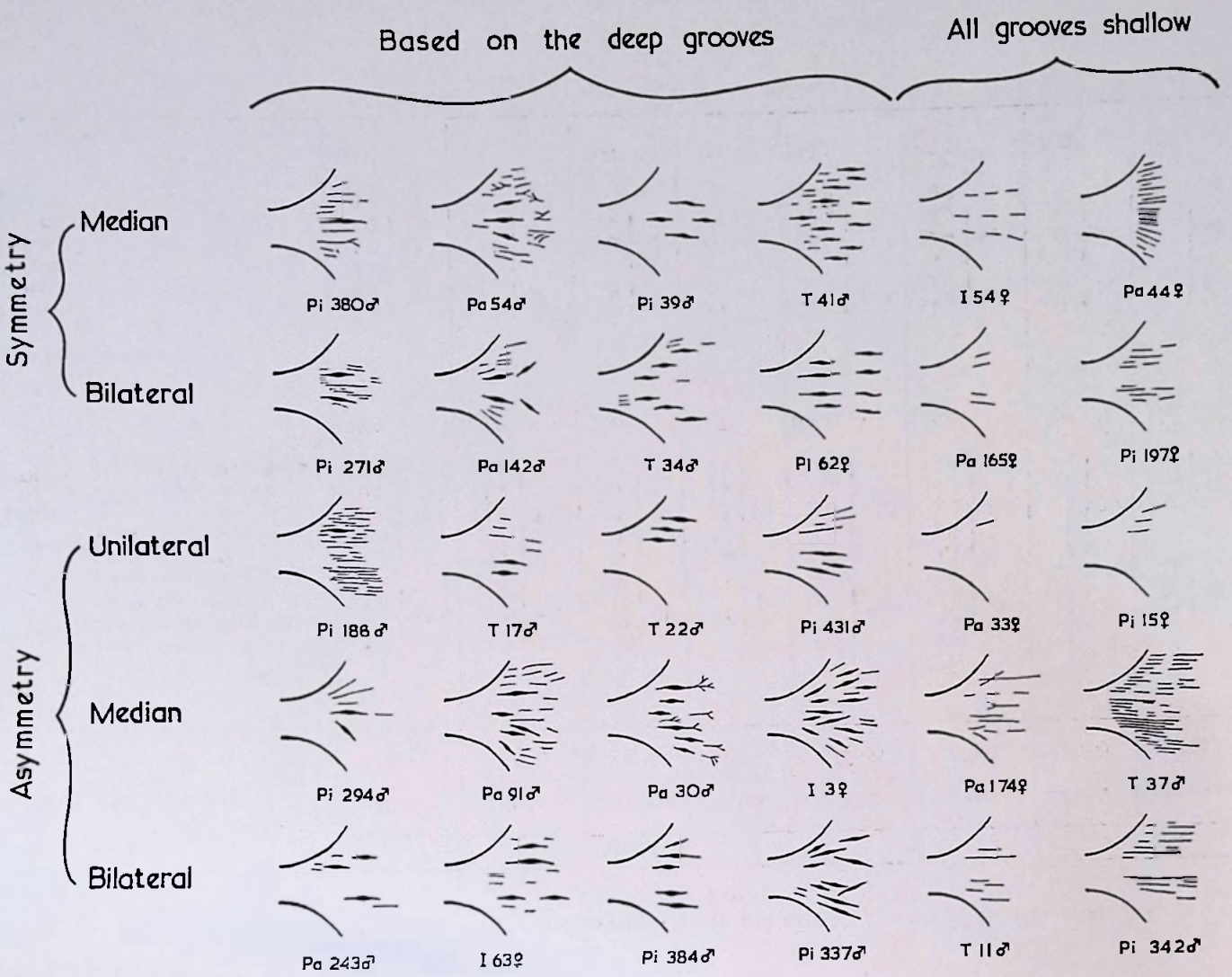


Fig. 11. Examples of symmetry and asymmetry in the throat grooves of whales examined in Chile and Perú between 1959 and 1961.

of whales whose throat grooves were noted at the Azores in the North Atlantic, Clarke (1956, p. 247) also found a predominance of symmetrical patterns, and pointed out that these could all have sprung from the bilateral arrangement of two grooves found in most representatives of the Ziphiidae, and which could be regarded as the primitive arrangement.

*Numbers of grooves and body length.* Clarke (1956, p. 247) considered the possibility that numerous throat grooves in sperm whales might be a sign of ageing, akin to wrinkling of the neck in man, but he was unable to find any correlation of the numbers of grooves with age in his small sample. We have re-examined this possibility with the large amount of data from Chile and Perú, and Table 21 shows the average number of grooves at each metre of body length. Although there is within each length group a considerable range in the numbers of grooves, the average numbers of both deep and shallow grooves increases steadily from the smallest to the largest whales: the correlation is more obvious in males, but it may be seen also in females within their limited size range. The numbers of throat grooves, then, increase with age, or at least with body size so far as it is an indication of age. The increase may be something akin to wrinkling, but is more likely an accommoda-

Table 21. *Average numbers of throat grooves at each metre of body length in whales examined in Chile and Perú between 1959 and 1961.*

| Whale length m | Deep grooves | | | Shallow grooves | | | All grooves | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of whales | Range | Average | No. of whales | Range | Average | No. of whales | Range | Average |
| | | | | Males | | | | | |
| 6.0– 6.9 | 1 | 4 | 4 | 2 | 2–13 | 7.5 | 3 | 2–13 | 6.3 |
| 7.0– 7.9 | 5 | 0– 5 | 2.8 | 5 | 0–13 | 5.8 | 8 | 0–13 | 5.4 |
| 8.0– 8.9 | 25 | 0– 9 | 3.4 | 33 | 0–14 | 5.4 | 42 | 0–16 | 6.3 |
| 9.0– 9.9 | 72 | 0–10 | 3.8 | 116 | 0–45 | 6.1 | 141 | 0–55 | 6.9 |
| 10.0–10.9 | 183 | 0–14 | 3.3 | 234 | 0–37 | 6.6 | 283 | 0–39 | 7.6 |
| 11.0–11.9 | 155 | 0–41 | 4.1 | 170 | 0–33 | 8.3 | 208 | 0–41 | 9.8 |
| 12.0–12.9 | 98 | 1–12 | 4.6 | 101 | 1–50 | 10.3 | 131 | 1–50 | 11.4 |
| 13.0–13.9 | 128 | 1–20 | 4.6 | 122 | 1–35 | 10.8 | 150 | 2–38 | 12.7 |
| 14.0–14.9 | 87 | 1–13 | 4.9 | 98 | 1–60 | 13.4 | 110 | 4–60 | 15.8 |
| 15.0–15.9 | 103 | 1–19 | 5.3 | 106 | 1–46 | 13.1 | 115 | 2–56 | 16.8 |
| 16.0–16.9 | 43 | 2–38 | 5.5 | 41 | 2–50 | 14.1 | 48 | 4–52 | 16.9 |
| 17.0–17.9 | 3 | 3–10 | 6.0 | 3 | 8–33 | 17.7 | 3 | 15–38 | 23.7 |
| All whales | 903 | 0–41 | 4.29 | 1031 | 0–60 | 9.29 | 1242 | 0–60 | 10.82 |
| | | | | Females | | | | | |
| 6.0– 6.9 | | | | 1 | 7 | 7 | 1 | 7 | 7 |
| 7.0– 7.9 | 5 | 0–4 | 2.6 | 11 | 0–11 | 5.0 | 14 | 0–11 | 4.9 |
| 8.0– 8.9 | 43 | 0–6 | 3.4 | 82 | 0–15 | 4.7 | 102 | 0–15 | 5.2 |
| 9.0– 9.9 | 185 | 0–12 | 3.2 | 379 | 0–17 | 5.5 | 447 | 0–22 | 6.0 |
| 10.0–10.9 | 129 | 0–12 | 3.4 | 261 | 0–22 | 7.1 | 296 | 0–22 | 7.7 |
| 11.0–11.9 | 10 | 3–12 | 4.8 | 20 | 1–20 | 9.9 | 23 | 1–25 | 10.7 |
| All whales | 372 | 0–12 | 3.34 | 754 | 0–22 | 6.08 | 883 | 0–25 | 6.59 |

Table 22. *Average numbers of throat grooves in whales examined at Paita, Pisco, Iquique and Talcahuano between 1959 and 1961.*

| Locality | Males | | | | | |
|---|---|---|---|---|---|---|
| | Deep grooves | | Shallow grooves | | All grooves | |
| | No. of whales | Average | No. of whales | Average | No. of whales | Average |
| Paita | 591 | *4.04* | 688 | *8.15* | 818 | *9.76* |
| Pisco | 196 | *4.36* | 229 | *11.09* | 276 | *12.30* |
| Iquique | 91 | *5.4* | 87 | *11.7* | 118 | *12.8* |
| Talcahuano | 25 | *5.9* | 27 | *15.3* | 30 | *18.6* |
| Chile and Perú | 903 | *4.29* | 1031 | *9.29* | 1242 | *10.82* |
| | Females | | | | | |
| Paita | 238 | *3.17* | 536 | *6.08* | 607 | *6.59* |
| Pisco | 84 | *3.23* | 149 | *5.97* | 183 | *6.34* |
| Iquique | 46 | *4.4* | 56 | *5.8* | 80 | *6.6* |
| Talcahuano | 4 | *4.0* | 13 | *8.9* | 13 | *10.1* |
| Chile and Perú | 372 | *3.34* | *754* | *6.08* | 883 | *6.59* |

tion, as the whale grows, to the swallowing of progressively larger prey, for Beddard (1900, p. 183) and Boschma (1938, p. 157) have suggested that the grooves may allow distension of the throat when swallowing large prey. This would also explain why the ranges in numbers and the average numbers of grooves (Table 22) are greater in males than in females.

Table 22 presents the average numbers of throat grooves in the samples from each of the four localities. The table indicates an increase in the averages from north to south, which presumably reflects differences in the average ages of the whales caught at each locality, since migration, seasonal movements, breeding areas and segregation must result in a spacial distribution of the age classes in the sperm whale population off the west coast of South America. We have seen that the length frequencies of the samples suggest a progressive diminution in the proportion of younger whales from north to south of the region.

Except for Clarke's data from the North Atlantic, there is at present nowhere sufficient information on the throat grooves of sperm whales from other seas to make a useful comparison with the Southeast Pacific material.

*Cheek grooves*

On each side of the head of the sperm whale, above the upper jaw and at about one third of the distance from the gape to the end of the palate, there is a shallow but well-defined groove which is orientated vertically, that is,

transverse to the axis of the head (shown diagrammatically in Fig. 4, sketches no. 6 and nos. 10 & 11). These are the cheek grooves. They were not recorded from the sperm whale until Paliza (1964) described them in the foetuses from Perú. She found that they first appeared in foetuses larger than 0.75 m, and that all foetuses larger than 3.5 m in her sample bore them.

The cheek grooves were first noticed in postnatal animals, on the whaling platform at Paita on 13 July 1959, and afterwards during that year records of their presence were only made from time to time. But thereafter, at Paita in 1960 and at Pisco in 1961, they were looked for as a routine observation in all whales, with the following results:

| | *No. of whales* | | *Cheek grooves present* | |
|---|---|---|---|---|
| | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| Paita, 1960 | 337 | 246 | 336 | 246 |
| Pisco, 1961 | 283 | 187 | 283 | 187 |

Thus they were absent in only one out of 1,053 whales. At Iquique and Talcahuano they were noted several times in the logbooks, but they were not always looked for, so that we are unable to take into account the incidence in these two localities. However, the data from Paita and Pisco are sufficient to show that the cheek grooves are a small but constant feature in the external characters of the sperm whale.

As Table 23 shows, nearly all whales (98 %) have a single cheek groove on each side of the head. Rarely there may be more on one side than upon the other: in about 1 % of whales there is a single groove on one side and none on the other (shown by the first row of figures in Table 23), whilst in

Table 23. *Percentage frequencies of the numbers of cheek grooves in either cheek of whales examined in Chile and Perú between 1959 and 1961.*

| No. of grooves | Males | | Females | |
|---|---|---|---|---|
| | Left (*885*) | Right (*885*) | Left (*567*) | Right (*567*) |
| 0 | 1.2 | 0.9 | 1.0 | 0.7 |
| 1 | 98.4 | 98.9 | 97.4 | 98.2 |
| 2 | 0.2 | 0.1 | 0.7 | |
| 3 | | | | 0.2 |
| 4 | 0.1 | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | 0.9 | 0.9 |
| 8 | | 0.1 | | |
| Totals | 99.9 | 100.0 | 100.0 | 100.0 |

Table 24. *Length of the longest cheek groove as a percentage of total length in foetal and postnatal whales examined in Chile and Perú between 1959 and 1961.*

| Length in metres | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | No. of whales | Length of longest cheek groove | | | No. of whales | Length of longest cheek groove | | |
| | | Range m. | Average m. | Average as % of body length | | Range m. | Average m. | Average as % of body length |
| | Foetuses | | | | | | | |
| 0.75–0.99 | | | | | 2 | 0.02–0.03 | 0.025 | *2.8* |
| 1.00–1.49 | 7 | 0.02–0.06 | 0.037 | *3.1* | 5 | 0.01–0.03 | 0.024 | *1.9* |
| 1.50–1.99 | 5 | 0.04–0.07 | 0.054 | *3.1* | 2 | 0.04–0.05 | 0.043 | *2.2* |
| 2.00–2.49 | 5 | 0.05–0.06 | 0.054 | *2.5* | 3 | 0.05–0.06 | 0.053 | *2.4* |
| 2.50–2.99 | 3 | 0.03–0.08 | 0.053 | *1.9* | | | | |
| 3.00–3.49 | 4 | 0.08–0.12 | 0.098 | *2.9* | 5 | 0.03–0.10 | 0.053 | *1.7* |
| 3.50–3.99 | 7 | 0.03–0.18 | 0.087 | *2.3* | 5 | 0.07–0.12 | 0.092 | *2.5* |
| 4.00 | 1 | (0.07) | (0.07) | *(1.7)* | | | | |
| All foetuses | 32 | 0.02–0.18 | 0.063 | *2.5* | 22 | 0.01–0.12 | 0.052 | *2.2* |
| | Post natal whales | | | | | | | |
| 6.0– 6.9 | 3 | 0.10–0.20 | 0.15 | *2.2* | 1 | (0.20) | (0.20) | *(3.0)* |
| 7.0– 7.9 | 7 | 0.10–0.30 | 0.21 | *2.8* | 12 | 0.15–0.25 | 0.18 | *2.4* |
| 8.0– 8.9 | 22 | 0.10–0.40 | 0.25 | *2.9* | 59 | 0.15–0.35 | 0.23 | *2.7* |
| 9.0– 9.9 | 84 | 0.15–0.50 | 0.26 | *2.7* | 308 | 0.15–0.40 | 0.25 | *2.6* |
| 10.0–10.9 | 199 | 0.10–0.50 | 0.28 | *2.7* | 173 | 0.15–0.65 | 0.27 | *2.6* |
| 11.0–11.9 | 153 | 0.15–0.45 | 0.30 | *2.6* | 9 | 0.15–0.30 | 0.25 | *2.2* |
| 12.0–12.9 | 105 | 0.15–0.50 | 0.32 | *2.6* | | | | |
| 13.0–13.9 | 106 | 0.20–0.80 | 0.36 | *2.7* | | | | |
| 14.0–14.9 | 84 | 0.25–0.60 | 0.39 | *2.7* | | | | |
| 15.0–15.9 | 81 | 0.20–0.60 | 0.40 | *2.6* | | | | |
| 16.0–16.9 | 33 | 0.30–0.70 | 0.43 | *2.6* | | | | |
| 17.0–17.9 | 3 | 0.40–0.50 | 0.45 | *2.6* | | | | |
| All whales | 880 | 0.10–0.80 | 0.32 | *2.64* | 562 | 0.15–0.65 | 0.26 | *2.64* |

the remaining 1 % there may be as many as eight grooves present on one or other side.

The length of the cheek grooves ranges from 2 cm in foetuses to 80 cm in large males. In Table 24 the length of the longest groove present is established as a proportion of body length. In the small sample of foetuses the average length is 2.5 % of the body length in males and 2.2 % in females, but in the large sample of postnatal animals the average is the same in both sexes, being 2.64 % of the body length. Table 24 also shows that the proportion remains strikingly constant during growth: the head of the male gets much larger as the whale grows, but the cheek grooves, although on the head, keep pace with the body length and not with the head.

There is at present no information on the cheek grooves of sperm whales from other seas, but the right cheek groove in a large male at the Azores in the North Atlantic can be well seen in a photograph reproduced by Clarke (1954, Plate XVI, Fig. 5).

*Accessory grooves*

On the head and body of some whales there occur additional grooves, which are, of course, to be distinguished from healed scars due to the hooks and suckers of squids or to other agents of injury. These accessory grooves are mostly between 10 and 50 cm long and may be straight or curved. They are to be found on any part of the body, but Table 25 shows that they are commoner in males than in females, and most often are found in the umbilical region, and around the penis slit and the anus in males, and around the cloaca in females.

Paliza (1964) has recorded accessory grooves from 13 % of the foetuses from Perú larger than 1.00 m in length, where they usually occurred around the genital opening and the anus, and also on the postanal ventral hump.

Table 25 shows no great similarity in the frequency distributions of accessory grooves over the body surface of whales from the four localities, not even between Paita and Pisco, and it appears that the incidence of these grooves is so variable as to be of no practical use in comparing different stocks of whales. Clarke (1956, p. 248) has recorded some examples of accessory grooves from North Atlantic sperm whales, and the equivalents of all these are represented in Table 25.

Table 25. *Percentage frequencies of the distribution of accessory grooves on the body surface of whales examined in Chile and Perú between 1959 and 1961.*

| Part of the body | Paita | | Pisco | | Iquique | | Talca-huano | | Chile and Perú | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ♂♂ (835) | ♀♀ (673) | ♂♂ (283) | ♀♀ (187) | ♂♂ (119) | ♀♀ (84) | ♂♂ (32) | ♀♀ (13) | ♂♂ (1269) | ♀♀ (957) |
| Forehead | 0.8 | | | | | | | | 0.6 | |
| Around blowhole | 1.1 | 0.3 | 0.7 | | | 1 | | | 0.9 | 0.3 |
| Top and sides of the head | 1.4 | 0.1 | 0.4 | | | | | 8 | 1.0 | 0.2 |
| Back and flanks | 0.2 | | | | | | | | 0.2 | |
| Chest, between flippers | 5.4 | 1.9 | 3.2 | 1.6 | 4.2 | 1 | 3 | 23 | 4.7 | 2.1 |
| Umbilical region | 31.1 | 13.1 | 42.8 | 13.9 | 6.7 | 1 | 13 | 8 | 31.0 | 12.1 |
| Around penis slit | 42.9 | | 41.3 | | 29.4 | | 31 | | 41.0 | |
| Anus (♂♂) *or* Cloaca (♀♀) | 30.5 | 10.8 | 70.7 | 12.3 | 6.7 | 1 | 41 | 23 | 37.5 | 10.4 |
| Postanal ventral hump | 0.2 | 0.1 | | | | | 3 | | 0.2 | 0.1 |

## Teeth

This section is confined to the eruption of teeth and the variation of the numbers of erupted and unerupted teeth in sperm whales: results on the use of teeth in age determination will be included in a later publication of the present series.

Foetal development of teeth has been described by Paliza (1964) in the 157 foetuses from Perú. In foetuses of 0.36 m swellings begin to appear in the gum of the lower jaw, corresponding to the dental papillae within. In

the upper jaw also dental papillae are present in the gum at this foetal length, but they are never represented by swellings superficially. By the time the foetus grows to 0.65 m all the mandibular swellings are present.

The tooth counts in postnatal whales from Chile and Perú are from 1,277 males and 947 females.

*Mandibular teeth*

*Eruption and body length.* Table 26 shows that the functional teeth in the lower jar begin to erupt when males are between 6.8 and 8.6 m long (22 and 28 ft.) and females are between 7.5 and 9.3 m (25 and 31 ft.), and that the mean body length at which they erupt is almost the same in both sexes, being 7.9 m (26 ft.) for males and 8.2 m (27 ft.) for females.

These results from Chile and Perú somewhat extend the range of body length (8.4 to 9.5 m) for eruption of mandibular teeth given by Clarke (1956, p. 249) for a much smaller sample of females from the North Atlantic, where

Table 26. *Mandibular teeth. Eruption at length in whales examined in Chile and Perú between 1959 and 1961. All whales larger than 9.3 m had erupted teeth.*

| Length in metres | Males | | Females | |
|---|---|---|---|---|
| | Teeth not erupted | Teeth erupted | Teeth not erupted | Teeth erupted |
| 6.4 | 1 | | | |
| 6.5 | | | | |
| 6.6 | | | 1 | |
| 6.7 | | | | |
| 6.8 | | 1 | | |
| 6.9 | 1 | | | |
| 7.0 | | 1 | | |
| 7.1 | | | | |
| 7.2 | | | | |
| 7.3 | | | 1 | |
| 7.4 | 2 | | 1 | |
| 7.5 | 1 | | 1 | 1 |
| 7.6 | 2 | | 1 | 1 |
| 7.7 | | | 2 | 2 |
| 7.8 | 1 | 3 | 2 | 2 |
| 7.9 | 1 | | | |
| 8.0 | 1 | 1 | 1 | 5 |
| 8.1 | | | 3 | 3 |
| 8.2 | 1 | 4 | 1 | 2 |
| 8.3 | | 6 | 2 | 1 |
| 8.4 | 1 | 4 | 5 | 9 |
| 8.5 | 1 | 6 | 1 | 10 |
| 8.6 | | 2 | | 13 |
| 8.7 | | 9 | 2 | 11 |
| 8.8 | | 4 | | 17 |
| 8.9 | | 5 | 2 | 18 |
| 9.0 | | 5 | | 20 |
| 9.1 | | 10 | | 41 |
| 9.2 | | 11 | 1 | 33 |
| 9.3 | | 14 | | 49 |

the mean length was estimated at 8.8 m. They also confirm his suggestion that males and females cut their teeth at similar body lengths.

Clarke pointed out that, since sperm whales of the North Atlantic are weaned when about 6.7 m long, the teeth are not cut until some long time after the age at weaning. This is so for the majority of whales of the Southeast Pacific, although it is seen that in a few whales the teeth may begin to erupt at 6.8 m, about the length at weaning in the North Atlantic. However, the data available to us on stomach contents show, as did those of Clarke, that weaned whales without erupted teeth have no difficulty in securing ample quantities of the squid on which they mostly feed.

Table 27. *Mandibular teeth. Frequencies of their numbers in whales examined in Chile and Perú between 1959 and 1961.*

| Number of teeth | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Left side | | Right side | | Left side | | Right side | |
| | Counting all teeth | Counting only erupted teeth | Counting all teeth | Counting only erupted teeth | Counting all teeth | Counting only erupted teeth | Counting all teeth | Counting only erupted teeth |
| 1 | | 1 | | 3 | | 8 | | 4 |
| 2 | | 1 | | 3 | | 5 | | 5 |
| 3 | | 4 | | 2 | | 4 | | 5 |
| 4 | | 4 | | 2 | | 4 | | 4 |
| 5 | | 1 | | | | 7 | | 8 |
| 6 | | | | 2 | | 2 | | 3 |
| 7 | | 3 | | 1 | | 5 | | 3 |
| 8 | | 10 | | 4 | | 3 | | 3 |
| 9 | | 6 | | 5 | | 5 | | 7 |
| 10 | | 4 | | 7 | | 4 | | 7 |
| 11 | | 7 | | 7 | | 2 | | 3 |
| 12 | | 9 | | 9 | | 9 | | 7 |
| 13 | | 6 | | 6 | | 6 | | 8 |
| 14 | 1 | 16 | | 16 | | 9 | | 7 |
| 15 | | 21 | 1 | 28 | | 20 | | 13 |
| 16 | 1 | 41 | | 40 | | 11 | | 26 |
| 17 | | 40 | | 45 | 3 | 23 | | 18 |
| 18 | 4 | 64 | 5 | 66 | | 22 | 3 | 21 |
| 19 | 5 | 74 | 4 | 58 | 8 | 46 | 8 | 31 |
| 20 | 25 | 105 | 23 | 87 | 36 | 67 | 32 | 72 |
| 21 | 104 | 138 | 121 | 168 | 72 | 109 | 70 | 108 |
| 22 | 187 | 186 | 187 | 165 | 161 | 143 | 184 | 138 |
| 23 | 303 | 178 | 286 | 203 | 235 | 164 | 211 | 161 |
| 24 | 272 | 149 | 269 | 126 | 204 | 125 | 229 | 146 |
| 25 | 198 | 105 | 196 | 122 | 136 | 74 | 126 | 63 |
| 26 | 102 | 54 | 112 | 48 | 53 | 24 | 46 | 28 |
| 27 | 57 | 25 | 54 | 22 | 26 | 11 | 22 | 10 |
| 28 | 14 | 6 | 15 | 13 | 7 | 3 | 9 | 5 |
| 29 | 3 | 1 | 4 | 1 | 2 | 2 | 3 | 1 |
| 30 | 1 | | | | 1 | | 1 | |
| Totals | 1277 | 1259 | 1277 | 1259 | 944 | 917 | 944 | 915 |

Table 26 records simply the complete absence of erupted teeth or their presence, irrespective of whether one or a few or many had erupted. But teeth which have not erupted may be easily counted as a series of swellings along the gum (see Clarke 1956, Plate I, Fig. 6); in whales where a number of teeth have already erupted, these swellings are usually all at the back of the mouth, behind the last erupted tooth. In Table 27 it is seen that, whereas the total number of teeth present (comprising erupted and unerupted teeth together) may range on one or other side from 14 in males and 17 in females to a maximum of 30 in both sexes, the numbers erupted may be as few as one or as many as 29. This at once suggests that eruption of teeth is, at least for some whales, a gradual process over a period of time. Tables 28 and 29 confirm that this is so, for it is seen that the average numbers of all teeth present remain constant at each metre of whale length, whereas the average numbers of erupted teeth increase steadily with increasing size of the whale. Although there is a considerable range in the numbers of teeth erupted in individual whales at all lengths, it can be said that in general eruption of the teeth is not completed until males are 16 m (52 ft.) and females 11 m (36 ft.) long, when about 23 teeth will have erupted on each side of the lower jaw in both sexes.

Ivanova (1955) studied the eruption of teeth in 125 male and 25 female sperm whales from the Kurile Islands in the North Pacific: she also found that the process is in general protracted, the maximum number having emerged when males have grown to 15 m and females to 11 m. Matthews' text (1938, p. 121) and his Table VII appear to refer to counts of erupted teeth only, and neither he nor Clarke (1956, p. 250) found any correlation between the number of teeth and body length in southern whales and North Atlantic whales respectively, a result which can only be attributed to the smallness of their samples.

*Numbers of teeth.* Since the mandibular teeth erupt over a period of time, variation in the numbers of erupted teeth in a sperm whale population depends on the age structure of the population, and therefore it would be misleading to study such variation when looking for information on stock limits in whales from different localities or oceans. Only counts of all teeth, erupted and unerupted, are valid in such comparisons.

The frequencies of the total numbers of mandibular teeth in whales examined at Paita, Pisco, Iquique, and Talcahuano are given in Table 30 and in Figs. 12 and 13, which also reproduce Omura's results (1950, Figs. 57 and 58) for sperm whales from the coast of Japan. Table 31 records the average numbers of teeth, and the averages from the four localities are seen to be very close to each other. The three bimodal curves from Talcahuano and one bimodal curve from Iquique may be attributed to the smallness of the samples. Otherwise the curves for the left and right sides of the jaw at Paita and Pisco are almost identical for males and for females taken separately; and

Table 28. *Mandibular teeth. Males. Average numbers at each metre of body length in whales examined in Chile and Perú between 1959 and 1961.*

| Body length m. | No.* of whales | Left side | | | | | Right side | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total number of teeth | | Number of erupted teeth | | Percent erupted | Total number of teeth | | Number of erupted teeth | | Percent erupted |
| | | Range | Average | Range | Average | | Range | Average | Range | Average | |
| 6.0– 6.9 | 1 | (23) | (23) | (4) | (4) | 17 | (25) | (25) | (6) | (6) | 24 |
| 7.0– 7.9 | 4 | 19–28 | 22.5 | 4–12 | 8.5 | 38 | 18–25 | 22.0 | 3–12 | 7.8 | 35 |
| 8.0– 8.9 | 40 | 18–27 | 23.7 | 1–24 | 11.4 | 48 | 18–27 | 23.4 | 1–25 | 11.9 | 51 |
| 9.0 –9.9 | 150 | 14–27 | 23.3 | 4–25 | 17.6 | 75.5 | 15–27 | 23.5 | 1–27 | 17.8 | 75.7 |
| 10.0–10.9 | 290 | 19–30 | 23.8 | 3–27 | 20.4 | 85.7 | 18–29 | 23.6 | 4–26 | 20.3 | 86.0 |
| 11.0–11.9 | 212 | 18–29 | 23.5 | 11–28 | 21.5 | 91.5 | 20–28 | 23.7 | 14–28 | 21.8 | 92.0 |
| 12.0–12.9 | 134 | 20–28 | 23.7 | 16–28 | 22.8 | 96.2 | 21–29 | 23.6 | 16–28 | 22.7 | 96.2 |
| 13.0–13.9 | 152 | 20–28 | 23.6 | 19–28 | 23.0 | 97.5 | 20–28 | 23.6 | 18–28 | 23.1 | 97.9 |
| 14.0–14.9 | 109 | 19–28 | 23.7 | 17–28 | 23.2 | 97.9 | 20–28 | 23.8 | 17–28 | 23.3 | 97.9 |
| 15.0–15.9 | 117 | 20–29 | 23.8 | 19–29 | 23.3 | 97.9 | 19–28 | 23.8 | 19–29 | 23.5 | 98.7 |
| 16.0–16.9 | 47 | 20–28 | 23.3 | 20–27 | 23.0 | 99 | 19–28 | 23.0 | 18–28 | 22.7 | 99 |
| 17.0–17.9 | 3 | 23–26 | 24.7 | 19–26 | 23.3 | 94 | 22–26 | 24.3 | 19–26 | 23.3 | 96 |

* Whales in which no mandibular teeth had erupted are excluded from this table.

Table 29. *Mandibular teeth. Females. Average numbers at each metre of body length in whales examined in Chile and Perú between 1959 and 1961.*

| Body length m. | No.* of whales | Left side | | | | | Right side | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total number of teeth | | Number of erupted teeth | | Percent erupted | Total number of teeth | | Number of erupted teeth | | Percent erupted |
| | | Range | Average | Range | Average | | Range | Average | Range | Average | |
| 6.0– 6.9 | | | | | | | | | | | |
| 7.0– 7.9 | 6 | 22–24 | 22.5 | 1– 8 | 4.0 | 18 | † 22–24 | 23.3 | † 1– 9 | 4.2 | 22 |
| 8.0– 8.9 | 87 | 20–28 | 23.3 | 1–25 | 14.6 | 63 | (85) 19–28 | 23.0 | (85) 1–26 | 14.4 | 63 |
| 9.0– 9.9 | 499 | 17–30 | 23.3 | 1–28 | 21.1 | 90.2 | 18–30 | 23.3 | 1–28 | 21.2 | 91.0 |
| 10.0–10.9 | 301 | 19–29 | 23.4 | 12–29 | 22.6 | 96.6 | 18–29 | 23.4 | 13–29 | 22.6 | 96.6 |
| 11.0–11.9 | 24 | 20–26 | 22.7 | 19–26 | 22.4 | 99 | 20–27 | 23.1 | 20–26 | 23.0 | 100 |

* Whales in which no mandibular teeth had erupted are excluded from this table.

† In the 8.0—8.9 m length group the left tooth row was observed in 87 whales but the right in 85.

Table 30. *Mandibular teeth. Percentage frequencies of the numbers of all teeth (erupted and unerupted) in whales examined in Chile and Perú between 1959 and 1961.*

| Number of teeth | Left side | | | | | Right side | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Paita | Pisco | Iquique | Talcahuano | Chile and Perú | Paita | Pisco | Iquique | Talcahuano | Chile and Perú |
| | | | | | Males | | | | | |
| | *838* | *283* | *124* | *32* | *1277* | *838* | *283* | *124* | *32* | *1277* |
| 14 | | 0.3 | | | 0.08 | | | | | |
| 15 | | | | | | | 0.3 | | | 0.08 |
| 16 | 0.1 | | | | 0.08 | | | | | |
| 17 | | | | | | | | | | |
| 18 | 0.4 | | | 3 | 0.31 | 0.5 | | 0.8 | | 0.39 |
| 19 | 0.6 | | | | 0.39 | 0.5 | | | | 0.31 |
| 20 | 1.9 | 2.8 | 0.8 | | 1.96 | 2.1 | 0.7 | 2.4 | | 1.80 |
| 21 | 8.8 | 7.8 | 5.6 | 3 | 8.14 | 8.9 | 11.7 | 8.9 | 6 | 9.48 |
| 22 | 14.9 | 12.7 | 14.5 | 25 | 14.64 | 15.9 | 12.0 | 11.3 | 19 | 14.64 |
| 23 | 23.8 | 23.3 | 21.8 | 34 | 23.73 | 23.0 | 23.3 | 15.3 | 25 | 22.40 |
| 24 | 22.9 | 20.5 | 16.9 | 3 | 21.30 | 20.3 | 21.2 | 26.6 | 19 | 21.06 |
| 25 | 14.9 | 15.2 | 19.4 | 19 | 15.51 | 15.2 | 15.2 | 16.9 | 16 | 15.35 |
| 26 | 7.3 | 7.8 | 12.9 | 9 | 7.99 | 8.2 | 9.9 | 10.5 | 6 | 8.77 |
| 27 | 3.3 | 6.7 | 7.3 | 3 | 4.46 | 4.3 | 3.2 | 5.6 | 6 | 4.23 |
| 28 | 0.8 | 2.5 | | | 1.10 | 1.0 | 1.8 | 0.8 | 3 | 1.17 |
| 29 | 0.1 | 0.3 | 0.8 | | 0.23 | 0.1 | 0.7 | 0.8 | | 0.31 |
| 30 | 0.1 | | | | 0.08 | | | | | |
| Totals | 99.9 | 99.9 | 100.0 | 99 | 100.00 | 100.0 | 100.0 | 99.9 | 100 | 99.99 |
| | | | | | Females | | | | | |
| | *664* | *183* | *84* | *13* | *944* | *664* | *183* | *84* | *13* | *944* |
| 14 | | | | | | | | | | |
| 15 | | | | | | | | | | |
| 16 | | | | | | | | | | |
| 17 | 0.3 | 0.6 | | | 0.32 | | | | | |
| 18 | | | | | | 0.5 | | | | 0.32 |
| 19 | 0.9 | 0.6 | 1 | | 0.85 | 0.8 | 1.6 | | | 0.85 |
| 20 | 3.8 | 3.8 | 4 | 8 | 3.81 | 3.6 | 3.3 | 2 | | 3.39 |
| 21 | 8.3 | 6.0 | 5 | 15 | 7.63 | 7.7 | 6.0 | 6 | 23 | 7.42 |
| 22 | 17.3 | 15.8 | 14 | 38 | 17.06 | 19.3 | 19.1 | 20 | 31 | 19.49 |
| 23 | 25.6 | 24.0 | 23 | 15 | 24.89 | 23.3 | 21.3 | 20 | | 22.35 |
| 24 | 20.3 | 25.7 | 26 | | 21.61 | 22.4 | 28.4 | 29 | 31 | 24.26 |
| 25 | 14.3 | 15.3 | 14 | 8 | 14.41 | 12.8 | 14.2 | 15 | 15 | 13.35 |
| 26 | 5.1 | 4.9 | 10 | 15 | 5.61 | 5.1 | 4.4 | 5 | | 4.87 |
| 27 | 2.7 | 2.7 | 4 | | 2.75 | 2.9 | 0.6 | 2 | | 2.33 |
| 28 | 0.9 | 0.6 | | | 0.74 | 1.2 | 0.6 | | | 0.95 |
| 29 | 0.3 | | | | 0.21 | 0.3 | 0.6 | | | 0.32 |
| 30 | 0.2 | | | | 0.11 | 0.2 | | | | 0.11 |
| Totals | 100.0 | 100.0 | 101 | 99 | 100.00 | 100.1 | 100.1 | 99 | 100 | 100.01 |

although the modes of the aggregate frequencies for Southeast Pacific females show a difference of one, as between 23 on the left and 24 on the right, the average numbers of teeth left and right, and the standard errors of the averages, are just about identical. There is then, as Omura (1950, p. 97) has earlier observed for whales of the North Pacific, no difference between the numbers of teeth on the left and right hand sides of the jaw. Comparing now

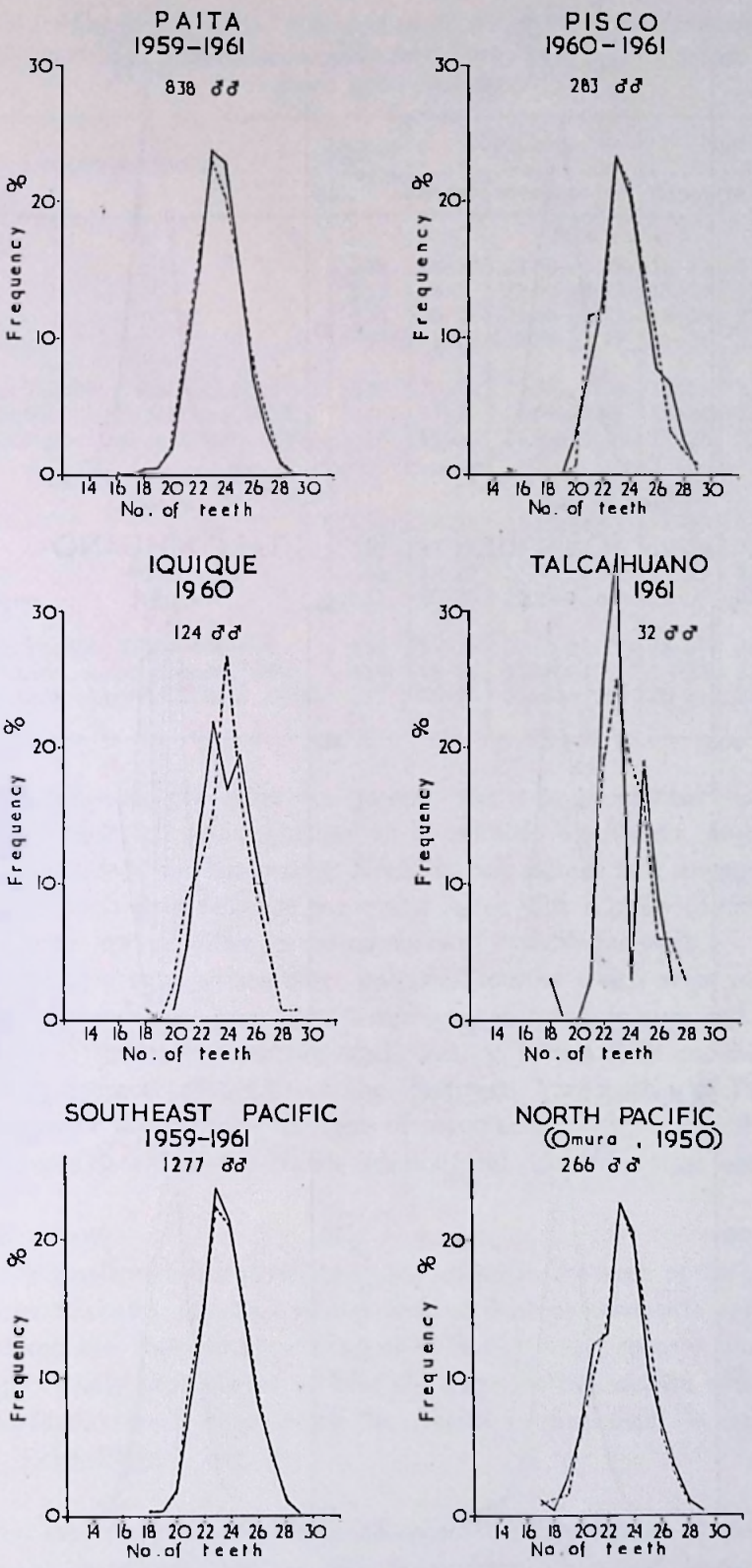


Fig. 12. Mandibular teeth. Males. Percentage frequencies of all teeth (erupted and unerupted) in whales examined in Chile and Perú between 1959 and 1961. Results from the North Pacific (Omura 1950) are also shown. The solid line represents the left side and the dotted line the right side.

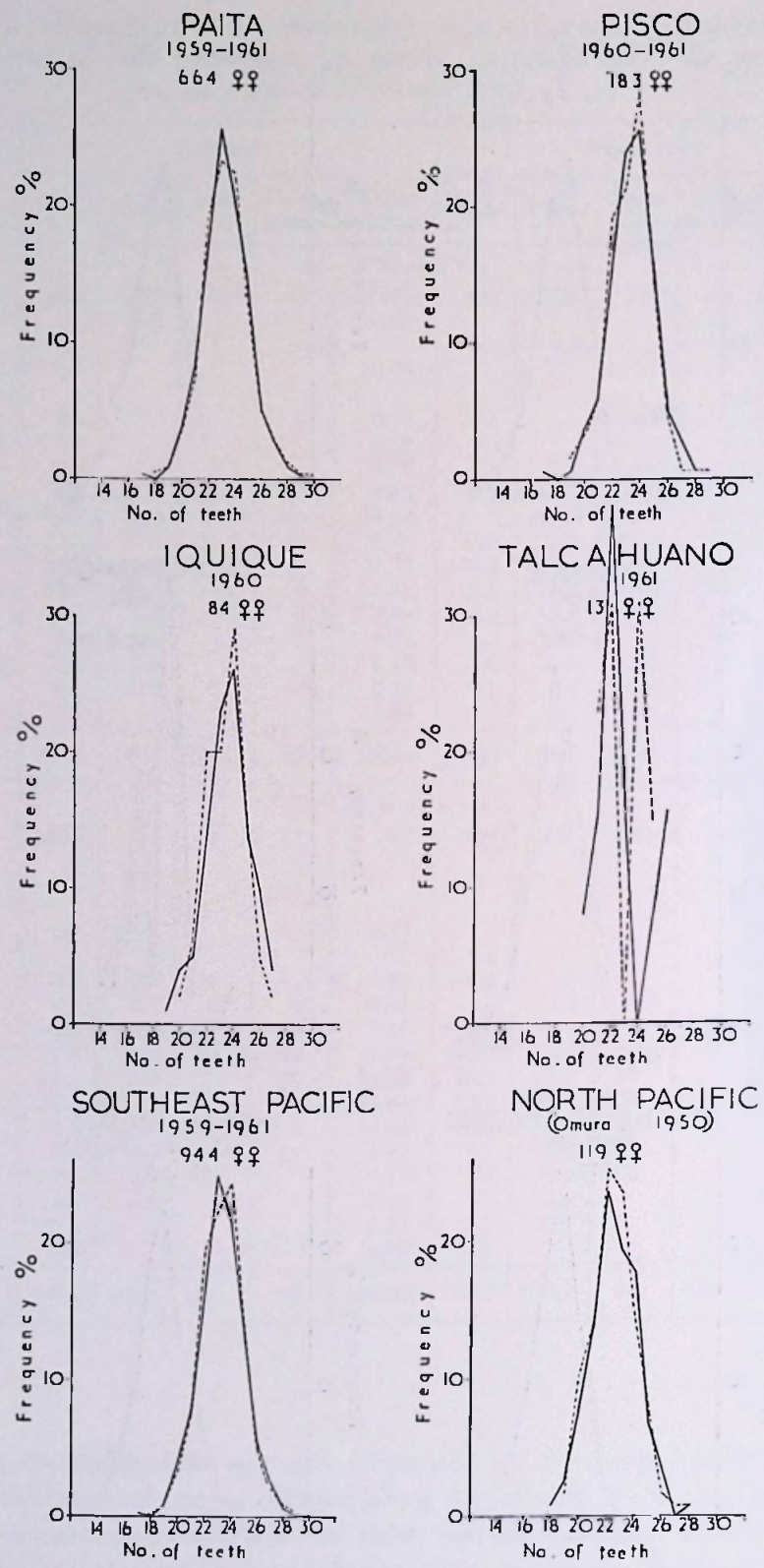


Fig. 13. Mandibular teeth. Females. Percentage frequencies of all teeth (erupted and unerupted) in whales examined in Chile and Perú between 1959 and 1961. Results from the North Pacific (Omura, 1950) are also shown.

Table 31. *Mandibular teeth. Average numbers of all teeth (erupted and unerupted) in whales examined in Chile and Perú, with a comparison of results from other oceans.*

| Locality or Ocean | No. of whales | Left side | | Right side | |
|---|---|---|---|---|---|
| | | Range | Average ± σ | Range | Average ± σ |
| | | Males | | | |
| Paita | 838 | 16–30 | 23.50±1.73 | 18–29 | 23.53±1.77 |
| Pisco | 283 | 14–29 | 23.99±1.82 | 15–29 | 23.67±1.83 |
| Iquique | 124 | 20–29 | 24.00±1.73 | 18–29 | 23.83±1.87 |
| Talcahuano | 32 | 18–27 | 23.34±1.77 | 21–28 | 23.78±1.73 |
| Southeast Pacific: Chile and Perú | 1277 | 14–30 | 23.66±1.76 | 15–29 | 23.60±1.79 |
| North Pacific: Japan (Omura, 1950) | 266 | 17–29 | 23.05±2.05 | 17–28 | 23.11±1.97 |
| North Atlantic: Azores (Clarke, 1956) | 14 | 19–26 | 22.93±1.28 | 19–26 | 22.85±1.55 |
| | | Females | | | |
| Paita | 664 | 17–30 | 23.32±1.73 | 18–30 | 23.33±1.76 |
| Pisco | 183 | 17–28 | 23.40±1.66 | 19–29 | 23.31±1.74 |
| Iquique | 84 | 19–27 | 23.58±1.66 | 20–27 | 23.44±1.48 |
| Talcahuano | 13 | 20–26 | 22.69±1.86 | 21–25 | 22.85±1.47 |
| Southeast Pacific: Chile and Perú | 944 | 17–30 | 23.35±1.73 | 18–30 | 23.33±1.70 |
| North Pacific: Japan (Omura, 1950) | 119 | 18–28 | 22.50±1.72 | 19–28 | 22.51±1.64 |
| North Atlantic: Azores (Clarke, 1956) | 12 | 20–26 | 23.92±1.32 | 20–26 | 24.08±1.19 |

males and females, the difference between the average numbers is so small (about 0.3 both left and right) as to be scarcely significant, and although Omura concluded from his smaller North Pacific sample that in general males have more teeth than females, we would agree with Clarke (1956, p. 251) that the sexes do not differ in the numbers of mandibular teeth.

Table 31 also summarizes other published results which refer to the total numbers of mandibular teeth. The samples are different in size, and that from the North Atlantic is extremely small, but, so far as they go, they do not suggest that sperm whales from the Southeast Pacific, North Pacific and North Atlantic differ in the numbers of mandibular teeth. It would be useful to have more data from the North Atlantic, and data from other seas.

*Maxillary teeth*

These are small, non-functional teeth embedded in the gum of the upper jaw of all sperm whales. In many whales none of them are erupted, and there are no swellings like those in the lower jaw to betray their presence. Those which do erupt usually protrude at or near the edges of the sockets which receive the mandibular tooth cusps when the mouth is shut (see Boschma, 1938; Clarke, 1956, Plate I, Fig. 7).

*Eruption and body length.* Table 32 shows the frequencies of the numbers of erupted maxillary teeth in the whales from Chile and Perú. The frequencies steadily decrease with increase in number of erupted teeth, until as

Table 32. *Maxillary teeth. Percentage frequencies of their numbers erupted in whales examined in Chile and Perú between 1959 and 1961.*

| Number of erupted teeth | Left side | | | | | Right side | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Paita | Pisco | Iquique | Talcahuano | Chile and Perú | Paita | Pisco | Iquique | Talcahuano | Chile and Perú |
| | Males | | | | | | | | | |
| | *837* | *282* | *125* | *32* | *1276* | *837* | *282* | *125* | *32* | *1276* |
| 0 | 74.7 | 72.0 | 84.8 | 84 | 75.31 | 75.4 | 72.0 | 84.0 | 91 | 75.86 |
| 1 | 5.6 | 6.0 | 0.8 | 9 | 5.33 | 5.7 | 7.1 | 4.0 | 6 | 5.88 |
| 2 | 5.8 | 6.4 | 3.2 | 3 | 5.64 | 4.1 | 5.3 | 4.0 | | 4.23 |
| 3 | 3.6 | 3.9 | 4.8 | | 3.68 | 3.7 | 5.0 | 2.4 | | 3.76 |
| 4 | 2.0 | 2.8 | 2.4 | 3 | 2.27 | 3.2 | 4.2 | 3.2 | | 3.37 |
| 5 | 1.9 | 2.1 | 1.6 | | 1.88 | 2.4 | 2.5 | 0.8 | | 2.19 |
| 6 | 1.6 | 3.9 | 1.6 | | 2.04 | 1.3 | 1.4 | 0.8 | 3 | 1.33 |
| 7 | 1.2 | 0.4 | 0.8 | | 0.94 | 1.1 | 1.1 | | | 0.94 |
| 8 | 1.6 | 1.1 | | | 1.25 | 1.3 | 0.7 | | | 1.02 |
| 9 | 0.8 | 0.4 | | | 0.63 | 0.5 | | 0.8 | | 0.39 |
| 10 | 0.5 | | | | 0.31 | 0.4 | 0.4 | | | 0.31 |
| 11 | 0.4 | 0.7 | | | 0.39 | 0.6 | 0.4 | | | 0.47 |
| 12 | 0.4 | | | | 0.24 | 0.4 | | | | 0.24 |
| 13 | | 0.4 | | | 0.08 | | | | | |
| Totals | 100.1 | 100.1 | 100.0 | 99 | 99.99 | 100.1 | 100.1 | 100.0 | 100 | 99.99 |
| | Females | | | | | | | | | |
| | *664* | *181* | *85* | *13* | *943* | *664* | *181* | *85* | *13* | *943* |
| 0 | 77.4 | 87.3 | 87 | 77 | 80.17 | 78.0 | 86.7 | 87 | 92 | 80.70 |
| 1 | 4.1 | 2.2 | 1 | 15 | 3.61 | 4.7 | 2.2 | 6 | 8 | 4.35 |
| 2 | 3.9 | 0.6 | 4 | 8 | 3.29 | 3.8 | 3.3 | 1 | | 3.39 |
| 3 | 4.7 | 3.3 | 2 | | 4.13 | 4.2 | 2.8 | 1 | | 3.61 |
| 4 | 3.5 | 2.8 | | | 2.97 | 3.2 | 1.6 | 1 | | 2.65 |
| 5 | 3.5 | 1.6 | 1 | | 2.86 | 3.2 | 1.6 | | | 2.54 |
| 6 | 1.4 | 1.6 | 1 | | 1.38 | 1.2 | 1.1 | | | 1.06 |
| 7 | 0.6 | | 1 | | 0.53 | 0.9 | 0.6 | 1 | | 0.85 |
| 8 | 0.7 | 0.6 | | | 0.64 | 0.3 | | 1 | | 0.32 |
| 9 | 0.1 | | 1 | | 0.21 | 0.4 | | | | 0.32 |
| 10 | | | 1 | | 0.11 | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | 1 | | 0.11 |
| 13 | 0.1 | | | | 0.11 | | | | | |
| 14 | | | | | | 0.1 | | | | 0.11 |
| Totals | 100.0 | 100.0 | 99 | 100 | 100.01 | 100.0 | 99.9 | 99 | 100 | 100.01 |

many as 13 may be erupted in males and 14 in females. This suggests that the maxillary teeth, like the mandibular ones, erupt gradually over a period of time, and it is confirmed by Tables 33 and 34 which show that in both sexes the proportions of whales with erupted maxillary teeth increase steadily with increasing body length. In those males where teeth erupt, they do not begin to do so until a length of 10 m (33 ft.) is reached, and thereafter the average numbers of teeth erupted increase as the whale grows (Table 33). Females with erupted teeth are not smaller than 9 m (30 ft.), but at greater size the average numbers of teeth erupted remain constant (Table 34): possibly, when maxillary teeth erupt in females, they do so more rapidly than in males, but length in females larger than 9 m is no reliable indication of age.

Table 33. *Maxillary teeth. Males. Frequencies of eruption and the numbers erupted at each metre of body length in whales examined in Chile and Perú between 1959 and 1961.*

| Body Length m. | Number of whales | Left side | | | Right side | | |
|---|---|---|---|---|---|---|---|
| | | % with teeth erupted | Nos. of erupted teeth | | % with teeth erupted | Nos. of erupted teeth | |
| | | | Range | Average | | Range | Average |
| 6.0– 6.9 | 3 | 0 | – | – | 0 | – | – |
| 7.0– 7.9 | 11 | 0 | – | – | 0 | – | – |
| 8.0– 8.9 | 45 | 0 | – | – | 0 | – | – |
| 9.0– 9.9 | 150 | 0 | – | – | 0 | – | – |
| 10.0–10.9 | 292 | 5.8 | 1–7 | 2.6 | 6.2 | 1–5 | 1.8 |
| 11.0–11.9 | 213 | 11.3 | 1–9 | 2.8 | 11.7 | 1–9 | 2.9 |
| 12.0–12.9 | 134 | 32.1 | 1–9 | 3.1 | 29.9 | 1–9 | 3.0 |
| 13.0–13.9 | 152 | 42.1 | 1–13 | 3.7 | 43.4 | 1–11 | 3.6 |
| 14.0–14.9 | 110 | 56.4 | 1–12 | 4.1 | 52.7 | 1–12 | 4.0 |
| 15.0–15.9 | 116 | 62.9 | 1–12 | 4.3 | 61.2 | 1–12 | 4.2 |
| 16.0–16.9 | 46 | 65 | 1–10 | 4.0 | 63 | 1–12 | 4.2 |
| 17.0–17.9 | 4 | (50) | 2–3 | (2.5) | (50) | 1–4 | (2.5) |
| All whales | 1276 | 24.69 | 0–13 | 3.73 | 24.14 | 0–12 | 3.61 |

Table 34. *Maxillary teeth. Females. Frequencies of eruption and the numbers erupted at each metre of body length in whales examined in Chile and Perú between 1959 and 1961.*

| Body Length m. | Number of whales | Left side | | | Right side | | |
|---|---|---|---|---|---|---|---|
| | | % with teeth erupted | Nos. of erupted teeth | | % with teeth erupted | Nos. of erupted teeth | |
| | | | Range | Average | | Range | Average |
| 6.0– 6.9 | 1 | 0 | – | – | 0 | – | – |
| 7.0– 7.9 | 14 | 0 | – | – | 0 | – | – |
| 8.0– 8.9 | 106 | 0 | – | – | 0 | – | – |
| 9.0– 9.9 | 498 | 14.3 | 1–13 | 3.5 | 13.7 | 1–14 | 3.5 |
| 10.0–10.9 | 300 | 35.0 | 1–9 | 3.6 | 34.3 | 1–9 | 3.4 |
| 11.0–11.9 | 24 | 46 | 1–7 | 3.5 | 46 | 1–7 | 3.5 |
| All whales | 943 | 19.83 | 0–13 | 3.54 | 19.30 | 0–14 | 3.45 |

From these observations we should expect that the proportions of whales with erupted maxillary teeth would, like the average numbers of throat grooves (p. 48), increase from the north of the Southeast Pacific region, where the proportion of smaller, younger whales is believed to be greater (p. 18), towards the south of the region, but it must be said that the results from Paita, Pisco, Iquique, and Talcahuano in Table 35 suggest no such increase, and we are at loss to account for this, unless differences in the sizes of the samples are the cause.

Turning again to Tables 33 and 34, these show that in the aggregate there is no significant difference, either in males or in females, in the number of

Table 35. *Maxillary teeth. Percentages of whales with erupted teeth examined in Chile and Perú, and a comparison with results from other oceans.*

| Ocean and locality | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | No. of whales | % with teeth erupted | | No of whales | % with teeth erupted | |
| | | Left side | Right side | | Left side | Right side |
| Paita | 837 | *25.3* | *24.6* | 664 | *22.6* | *22.0* |
| Pisco | 282 | *28.0* | *28.0* | 181 | *12.7* | *13.3* |
| Iquique | 125 | *15.2* | *16.0* | 85 | *13* | *13* |
| Talcahuano | 32 | *16* | *9* | 13 | *23* | *8* |
| South-east Pacific: Chile and Perú | 1276 | *24.69* | *24.14* | 943 | *19.83* | *19.30* |
| Antarctic, S.Georgia (Matthews, 1938, Table VII) | 35 | *40* | *57* | | | |
| Antarctic, pelagic 1947/48 (Clarke, 1956, p. 251) | 97 | *52* (sides not distinguished) | | | | |
| S. Indian Ocean, Durban (Matthews, 1938, Table VII) | 18*L*, 19*R* | *39* | *42* | 9*L*, 8*R* | *11* | *25* |
| North Pacific, Japan (Omura, 1950, Table 43) | 263 | *19.4* | *24.0* | 118 | *17.6* | *18.6* |
| North Pacific, Kurile Is. (Ivanova, 1955, Table 2, Measurements 48 and 49). | 122 | *24.6* (sides not distinguished) | | 25 | *20* (sides not distinguished) | |
| North Atlantic, Azores (Clarke, 1956, Table 9) | 12 | *36* | *36* | 9 | *11* | *11* |

teeth which erupt on the right and left sides of the jaw. The average numbers of teeth, for all whales where teeth are erupted, is fractionally greater, both left and right, for males than for females: if this is significant it could be explained by the greater growth of the males, which would also explain why the maxillary teeth erupt perhaps a little more frequently in males (24 %) than in females (20 %).

However, since the proportions of whales with erupted maxillary teeth increase with age, as do also (at least in males) the numbers of teeth erupted, it follows that the study of variation in erupted maxillary teeth becomes as misleading as that of variation in erupted mandibular teeth when looking for any racial differences. Thus, both Omura (1950, p. 97) and Clarke (1956, p. 251) have compared their results with those of Matthews (1938, p. 121), and have considered whether maxillary teeth might be erupted more often in southern than in northern sperm whales. But if we compare, as in Table 35, the available information from various seas on eruption of maxillary teeth, the observed differences now become explicable. Outside polar seas, where the range of body length is large, as indicated by the presence of both males and females in the samples, and where these samples are not unduly small in size, the proportions of either sex with maxillary teeth erupted are seen

Table 36. *Maxillary teeth. Frequencies of the numbers, and the average numbers, of all teeth (erupted and unerupted) in whales examined at Iquique and Talcahuano between 1960 and 1961.*

| No. of teeth | Iquique 1960 | | | | Talcahuano 1961 | | | | Southeast Pacific | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males | | Females | | Males | | Females | | Males | | Females | |
| | Left | Right | Left | Right | Left | Right | Left | Right | Left | Right | Left | Right |
| 6 | | | 1 | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 |
| 7 | 2 | 2 | 1 | 1 | 1 | 1 | | | 3 | 3 | 1 | 1 |
| 8 | 2 | 2 | 1 | 1 | | | 1 | 1 | 2 | 2 | 2 | 2 |
| 9 | | | 1 | 1 | | | | | | | 1 | 1 |
| 10 | 2 | 2 | | | 1 | 1 | | | 3 | 3 | | |
| 11 | 1 | 1 | 1 | | 2 | 2 | | | 3 | 3 | 1 | |
| 12 | | | | 1 | | | | | | | | 1 |
| 13 | | | | | | | | | | | | |
| 14 | | | | | | | 1 | | | | 1 | |
| 15 | | | | | | | | 1 | | | | 1 |
| Nos of whales | 7 | | 5 | | 5 | | 2 | | 12 | | 7 | |
| Average nos of teeth ± σ | 8.7±1.6 | 8.7±1.6 | 8.2±1.9 | 8.4±2.3 | 9.0±2.4 | 9.0±2.4 | 11.0±2.5 | 11.5±2.6 | 9.7±1.7 | 9.7±1.7 | 9.0±2.7 | 9.3±3.1 |

to be very similar in the Southeast Pacific and in the North Pacific, represented by both the coast of Japan and the Kurile Islands. On the other hand, the results from Antarctic males, both from South Georgia and the 1947/48 pelagic catch, indicate that more than 50 % of these bore erupted maxillary teeth. But these Antarctic males were all animals between 14 and 17 m long (Matthews, 1938, Fig. 67; Clarke, *unpublished information)*, and Table 33 shows that more than 50 % of males in this size range may be expected to have erupted maxillary teeth. There is consequently no reason to think that the eruption of teeth in the upper jaw is different in sperm whales from different seas.

*Numbers of teeth.* Comparative studies on the variation of maxillary teeth must be based, as with mandibular teeth, on counts of the total number of teeth present. Such information is difficult to obtain. Although there is no difficulty in extracting one or two protruding teeth for purposes of age determination, the dissection and searching of the length of the gums of the upper jaw is laborious and time-consuming; nor is it practicable to recover such small teeth after the whale is cooked. However, at Iquique in 1960 and at Talcahuano in 1961, the palates and gums of twelve males and seven females were stripped and all the maxillary teeth counted (Table 36). So far as may be judge from this small sample, there is nothing to suggest that whales from Iquique and from Talcahuano differ in the variation of the total numbers of their maxillary teeth. No difference is seen between the left and the right sides of the jaw. The numbers on each side range from six to 11 teeth in males and from six to 15 in females, although this difference between the ranges would probably disappear in a larger sample. In both males and females the average number of maxillary teeth is seen to be between nine and ten on each side. Paliza (1964) found ten maxillary teeth under the gums of a female foetus of 0.91 m from Perú, and one of us (Anelio Aguayo) collected all the maxillary teeth, eight from the left side and ten from the right side, of a female foetus 4.00 m long at Talcahuano in February 1964.

Ohsumi, Kasuya & Nishiwaki (1963, p. 16) say that 'sperm whales possess about 13 pairs of teeth in their upper jaw', but they offer no supporting data. Apart from their general statement, the only information known to us from other seas, and where the counts are certainly complete, is provided by Boschma (1938) who described exhaustively the maxillary teeth of two male sperm whales washed ashore in the Netherlands in 1937. The larger whale, 18 m long, bore 15 teeth in each side of the upper jaw, and nine of these protruded on each side; the smaller whale of 16 m bore nine maxillary teeth on the right and eight on the left, and none of these were erupted. These numbers, from eight to 15, are within the range in numbers of maxillary teeth in our sample from the Southeast Pacific. More information is required, although it is unlikely that sperm whales from different seas, which do not appear to differ in the total numbers of their mandibular teeth (p. 31), would be found to differ in the numbers of their maxillary teeth.

## Conclusion

A main object of the present study has been to see whether the observed variation in size range, external characters and teeth of sperm whales sampled from four localities on the west coast of South America can help to decide whether or not these whales are part of a single, continuous stock in the Southeast Pacific; and, further, to see whether the variation is similar to, or different from, what is known of variation in these characters in stocks of sperm whales in other oceans. A summary comparison of our findings is given in Table 37.

The close similarity in the variation at Paita and at Pisco, for all the characters studied, leaves us in no doubt that, so far as the evidence from external characters and teeth is concerned, the whales off Paita and Pisco belong to the same stock. The samples were large from Paita and substantial from Pisco, but further south they were much smaller from Iquique, and those from Talcahuano were very small. However, the only character where the results from Iquique and Talcahuano seemed to conflict with those from Paita and Pisco was the incidence of the head whorl, and since this is a character liable to subjective differences in its appraisal, we may recall that the observers at Iquique and Talcahuano were different from those at Paita and Pisco. This being so, and although it is desirable that more whales be examined at Iquique and especially at Talcahuano, the results summarized in Table 37 have encouraged us to lump the data together for the time being and to consider the sperm whales off Paita, Pisco, Iquique, and Talcahuano, so far as can be judged from the external characters and teeth, to be part of a single continuous stock in the Southeast Pacific.

Compared with that from the Southeast Pacific, the samples from other oceans are relatively small, being for no character as many as 300 males or 200 females, and for certain characters as few as a dozen of either sex, or absent altogether (Table 37). The largest samples refer to the eruption of mandibular and maxillary teeth, and the numbers of mandibular teeth, and here we have observed no differences. For the number of posterior dorsal humps, the incidence of anterior dorsal humps, the throat grooves, the cheek grooves, the incidence and distribution of accessory grooves, and the total numbers of maxillary teeth, there is either no information available, or the little that exists does not conflict with the results from the Southeast Pacific but is insufficient for a comparison. There may be differences in the frequencies of colour markings in whales from different oceans, but the samples outside the Southeast Pacific are either small or the data are not sufficiently detailed, or both. There are differences also in the incidence and development of the head whorl, but here, as in Chile and Perú, there may be subjective differences of interpretation. More information would be required for a firm opinion, but on present evidence there seems nothing so far to suggest that

Table 37. *Summary comparison of size range, external characters and teeth of sperm whales from four localities in the Southeast Pacific and from other seas.*

| Character | Comparing samples from Paita (855♂♂, 685♀♀), Pisco (284♂♂, 189♀♀), Iquique (124 ♂♂, 84♀♀) and Talcahuano (32♂♂, 13♀♀). | Comparing the aggregate Southeast Pacific sample (1295♂♂, 971♀♀) with samples from other seas. |
|---|---|---|
| Length frequencies | Suggest a diminution in the proportion of smaller, younger whales from north to south. | — |
| Size range | No differences not explicable from the different sizes of the samples. | Maximum sizes in the Southeast Pacific not less than those attained in other seas. |
| Colour markings | Almost identical at Paita and Pisco. No differences from Iquique and Talcahuano not explicable by the different sizes of the samples and possible subjective differences in recording. | Samples from the Antarctic (Ohno & Fujino, 1952), Antarctic and South Indian Ocean (70 whales, Matthews, 1938), North Pacific (231 whales, Omura, 1950; 103♂♂, 97♀♀, Gudkov, 1963), and North Atlantic (33 whales, Clarke, 1956) show some differences but are insufficient in quantity or detail, or both, for judgment. |
| Head whorl (a character of doubtful value because of subjective differences in recording) | No differences between Paita and Pisco, but twice as many males and females at Iquique and Talcahuano had no head whorl as compared with Paita and Pisco. | Sample from the North Pacific (150♂♂, 23♀♀, Omura, 1950), shows differences in development of the whorl. Proportions of whales with the whorl are similar in the Southeast Pacific, Antarctic (males, Ohno & Fujino, 1952) and North Pacific, but twice those in the Antarctic and South Indian Ocean according to Matthews (70 whales). |
| Number of posterior dorsal humps | Similar at Paita, Pisco and Iquique, and no differences at Talcahuano not explicable by the different sizes of the samples. | Information from the North Atlantic (17♂♂, 12♀♀, Clarke, 1956) and general statements from other seas do not conflict, but are insufficient. |
| Incidence of anterior dorsal humps | A rare character occuring in males only and not considered by separate localities. | No information from other seas. |
| Throat grooves | Major aspects of the frequency distributions are similar at Paita, Pisco, and Iquique, and data from Talcahuano do not conflict but are insufficient. An increase in the average numbers of grooves from north to south is explained by the age (as length) distributions of the samples. | No information except a little from the North Atlantic (17♂♂, 11♀♀) which does not conflict. |
| Cheek grooves | Patterns of symmetry and asymmetry are in general similar. | |
| Incidence and distribution of accessory grooves | Established as a constant character of the sperm whale from data from Paita and Pisco. | No information on variation from other seas. |
| Eruption of mandibular teeth | A character too variable for comparison by localities. | Accessory grooves mentioned from the North Atlantic (Clarke, 1956). |
| | Not considered by separate localities. | Teeth erupt at a similar length (8·8 m.) in females of the North Atlantic (148♂♂, 174♀♀, Clarke, 1956). Eruption is completed at similar lengths, 15 m. for males and 11 m. for females, in the North Pacific (122♂♂, 25♀♀, Ivanova, 1955). |
| | Teeth begin to erupt at an average length of 7·9 m. in males and 8·2 m. in females. Eruption is in general completed when males are 16 m. and females 11 m. long. | |
| Numbers of mandibular teeth (erupted and unerupted) | No significant differences. | No significant differences in samples from the North Pacific (266♂♂, 119♀♀, Omura, 1950) and North Atlantic (14♂♂, 12♀♀, Clarke, 1956). |
| Proportions of whales with erupted maxillary teeth. | An expected increase in the proportions from north to south is not encountered, possibly because of the different sizes of the samples. | No differences in this respect between whales from the Southeast Pacific, South Indian Ocean, Antarctic, North Pacific and North Atlantic which are not explicable by the age (as length) distribution of the samples (Table 35). |
| Numbers of maxillary teeth (erupted and unerupted). | Nothing in the ranges and average numbers to suggest differences between samples from Iquique (7♂♂, 5♀♀) and from Talcahuano (5♂♂, 2♀♀), being all those available. | No information except from two male whales from the North Sea (Boschma, 1938), where the numbers were within the range of those from the Southeast Pacific sample. |

sperm whales from different oceans are in general different in the variation of their external characters and teeth.

It may be that, when sufficient information does become available from whales of other seas, no significant differences will be revealed in the variation of their external characters and teeth, which would mean that these characters can be of little help in establishing the limits of the sperm whale stocks. Here the direct approach by whale marking is likely to be most informative; and there are also the study of body proportions, and of possible differences in the rhythm and duration of the sexual cycle, such as have already interested some authors and which we shall be discussing in future papers in this series.

## Summary

The first two parts are presented of a series of papers being prepared on the biology of sperm whales of the Southeast Pacific Ocean, which are part of a report required by a contract between the Food and Agriculture Organisation of the United Nations and the National Institute of Oceanography of the United Kingdom.

The *first part* is a general introduction to the series, and includes acknowledgments for assistance, a review of the material available, and some account of the methods of recording in the field. The Southeast Pacific is an important sperm whaling ground where in the decade 1956—65 shore stations in Chile and Perú took one fifth of the world sperm whale catch. Organised research on the sperm whale stocks was begun by the governments of Chile, Ecuador and Perú in 1958, with the technical assistance of the Food and Agriculture Organisation of the United Nations and under the aegis of the Permanent Commission for the Exploitation and Conservation of the Marine Resources of the South Pacific. A part of the research was done at field laboratories set up in whaling stations at Paita and Pisco in Perú and at Iquique and Talcahuano in Chile, where between 1959 and 1961 there were examined 2,266 sperm whales, comprising 1,295 males and 971 females. Because the area sampled extends through two thousand miles of latitude, the data from Paita, Pisco, Iquique, and Talcahuano are for most parts of the report examined separately, and then, wherever possible, lumped together for a comparison of Southeast Pacific whales with those from other seas.

The *second part* analyses size range and distribution of the sample and the variation in external characters and teeth.

Length frequencies suggest that there is a progressive diminution in the proportions of the smaller, younger whales from north to south of the region. The maximum sizes of sperm whales in the Southeast Pacific are not less than those attained in other seas.

Colour variation is analysed as the frequencies of 18 categories of markings, and there are no differences between males and females.

Attempts to correlate the degree of development of the head whorl with body length and with stages towards physical maturity indicate that the head whorl does not develop with age. It is well-developed rather more often in males than in females.

The dorsal fin is well or moderately developed in both males and females, the very low hump being rare.

In both sexes the numbers of posterior dorsal humps (which do not increase with age) range from one to nine with normal frequency distributions around five humps.

From one to six humps *anterior* to the dorsal fin occur in 0.7 % of males but in no females.

Throat grooves are entirely absent in 0.9 % of males and 3.4 % of females, and in those whales with throat grooves the sexes differ also in the proportions having all the grooves deep, or all shallow, or having both deep and shallow grooves present. Ranges in the numbers of deep and shallow grooves are greater in males than in females, but both sexes show peaks at two and four grooves in frequency distributions of deep grooves and of all grooves together. An analysis of the patterns of symmetry and asymmetry of the grooves shows a general similarity between males and females. In patterns based on deep grooves the largest group is that of bilateral symmetry of two or four grooves. In general the numbers of both deep and shallow grooves increase with body length, possibly as an accommodation to the swallowing of progressively larger prey. The average numbers of throat grooves increase from north to south, suggesting an increase in the average age (as body length) of the population.

A vertical groove on either side of the head, about one third of the distance between the gape and the end of the palate, is recognised as a constant feature in sperm whales. The average length of this cheek groove in the Southeast Pacific sample is 2.64 % of the body length in both males and females. 98 % of whales have a single groove on either side, but in the remaining 2 % the groove may be absent on one or other side, or as many as eight grooves may be present.

The incidence and distribution of accessory grooves on the body surface show much variation, but accessory grooves are commoner on males than on females and they usually occur in the umbilical, genital and anal regions.

Mandibular teeth begin to erupt at an average length of 7.9 m (26 ft.) in males and 8.2 m (27 ft.) in females. In general the teeth erupt gradually and eruption is not completed until males are 16 m (52 ft.) long and females 11 m (36 ft.) long, when about 23 teeth will have erupted in both sexes. The frequencies of the total numbers of mandibular teeth (erupted and unerupted) show no differences between the left and right sides of the jaw, nor between males and females.

24 % of males and 20 % of females bear erupted maxillary teeth, ranging on either side from one to 13 in males and one to 14 in females. When

maxillary teeth erupt in sperm whales from this region, they do not begin to do so until males are 10 m (33 ft.) and females 9 m (30 ft.) long, and thereafter the proportions of whales with erupted teeth increase with body length. The numbers of all maxillary teeth (erupted and unerupted) in a small sample of 12 males and seven females from Iquique and Talcahuano only, ranged from six to 15 on either side, the average number being between nine and ten for both males and females.

There are no differences between whales from Paita and Pisco in the variation of the characters investigated, and such differences as appear in results from Iquique and Talcahuano are explicable by the smaller samples or subjective differences in recording. For the present, therefore, and only so far as can be judged from external characters and teeth, whales from these four localities are considered to be part of a single, continuous stock in the Southeast Pacific. Such information as exists on the variation of these characters in sperm whales from other seas suggests no significant differences (Table 37), but it is insufficient for a valid comparison.

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# APPENDIX

Length frequencies of sperm whales examined at Paita, Pisco, Iquique and Talcahuano by months and years between 1959 and 1961.

| | | |
|---|---|---|
| Table | $A_{1-4}$ | Paita |
| | $B_{1-3}$ | Pisco |
| | C | Iquique |
| | D | Talcahuano |

Table $A_1$. *Paita 1959.*

| Length m. | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | | Total | | Percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 | | *0.4* | |
| .5 | | | | | | | | | | | | | | | | | 2 | | 2 | | 1 | 1 | | 1 | 1 | 6 | *0.4* | *4.0* |
| 9.0 | | | | | | | | | | | 1 | | | | 1 | | 1 | 4 | 1 | 2 | | 1 | 1 | 3 | 4 | 11 | *1.7* | *7.3* |
| .5 | | | | | | | | | | | 2 | 5 | 1 | | 3 | | 3 | 10 | 2 | 11 | 2 | 7 | 3 | 9 | 13 | 45 | *5.7* | *29.8* |
| 10.0 | | | | | | | | | | | | 3 | 4 | 4 | 6 | | | 6 | 1 | 10 | 7 | 11 | 5 | 11 | 17 | 51 | *7.4* | *33.8* |
| .5 | | | | | | | | | | | 1 | 1 | 2 | 4 | 3 | 2 | 5 | 8 | 5 | 8 | 5 | 6 | 6 | 1 | 27 | 30 | *11.7* | *19.9* |
| 11.0 | | | | | | | | | | | | 2 | 4 | | 1 | 1 | 2 | 2 | 3 | 1 | 6 | | 4 | 1 | 20 | 7 | *8.7* | *4.6* |
| .5 | | | | | | | | | | | 3 | 1 | 1 | | 2 | | 3 | | 5 | | 2 | | | | 16 | 1 | *7.0* | *0.7* |
| 12.0 | | | | | | | | | | | | | | | 3 | | 2 | | 2 | | 4 | | | | 11 | | *4.8* | |
| .5 | | | | | | | | | | | 5 | | | | 3 | | 3 | | 1 | | 1 | | | | 13 | | *5.7* | |
| 13.0 | | | | | | | | | | | 3 | | | | 6 | | 3 | | 2 | | 2 | | 1 | | 17 | | *7.4* | |
| .5 | | | | | | | | | | | 2 | | 1 | | 5 | | 1 | | | | 3 | | 2 | | 14 | | *6.1* | |
| 14.0 | | | | | | | | | | | 1 | | 2 | | | | 1 | | | | 3 | | | | 7 | | *3.0* | |
| .5 | | | | | | | | | | | 2 | | 1 | | 4 | | 1 | | 1 | | 4 | | | | 13 | | *5.7* | |
| 15.0 | | | | | | | | | | | | | 2 | | 3 | | 2 | | 2 | | 2 | | 2 | | 13 | | *5.7* | |
| .5 | | | | | | | | | | | 1 | | 2 | | 4 | | 1 | | 2 | | 4 | | 2 | | 16 | | *7.0* | |
| 16.0 | | | | | | | | | | | 2 | | 2 | | 2 | | 1 | | 2 | | 7 | | 1 | | 17 | | *7.4* | |
| .5 | | | | | | | | | | | | | 1 | | 2 | | | | 3 | | | | | | 6 | | *2.6* | |
| 17.0 | | | | | | | | | | | 2 | | | | | | | | | | | | 1 | | 3 | | *1.3* | |
| .5 | | | | | | | | | | | | | | | | | 1 | | | | | | | | 1 | | *0.4* | |
| | | | | | | | | | | | 25 | 12 | 23 | 8 | 38 | 13 | 30 | 32 | 32 | 34 | 54 | 26 | 28 | 26 | 230 | 151 | *100.0* | *100.1* |

Table $A_2$. *Paita 1960.*

| Length m. | Jan ♂♂ | Jan ♀♀ | Feb ♂♂ | Feb ♀♀ | Mar ♂♂ | Mar ♀♀ | Apr ♂♂ | Apr ♀♀ | May ♂♂ | May ♀♀ | Jun ♂♂ | Jun ♀♀ | Jul ♂♂ | Jul ♀♀ | Aug ♂♂ | Aug ♀♀ | Sep ♂♂ | Sep ♀♀ | Oct ♂♂ | Oct ♀♀ | Nov ♂♂ | Nov ♀♀ | Dec ♂♂ | Dec ♀♀ | Total ♂♂ | Total ♀♀ | Percent ♂♂ | Percent ♀♀ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | 2 | 2 | | | 1 | | | | | | | | 1 | | | | | | 2 | | | 2 | 6 | *0.6* | *2.4* |
| .5 | | 1 | | 1 | 3 | 1 | | | | | | | | | 1 | 1 | | 1 | | | | 3 | | | 4 | 8 | *1.2* | *3.2* |
| 9.0 | | 6 | 1 | 5 | | 9 | 1 | 3 | | 5 | | 2 | | 1 | | 1 | 2 | 2 | 1 | 2 | 1 | 2 | | | 6 | 38 | *1.8* | *15.1* |
| .5 | 2 | 6 | | 15 | 3 | 13 | 2 | 4 | 1 | 10 | 2 | 1 | 1 | 1 | 1 | 7 | 1 | 7 | 1 | 5 | | 3 | | | 14 | 72 | *4.1* | *28.7* |
| 10.0 | 5 | 6 | 5 | 14 | 10 | 10 | 7 | 6 | | 15 | 2 | 7 | | 3 | 2 | 5 | 1 | 2 | 1 | 6 | 9 | 7 | | | 42 | 81 | *12.3* | *32.3* |
| .5 | 2 | | 7 | 8 | 5 | 6 | 4 | 7 | 8 | 4 | | 3 | | 1 | 5 | 3 | 5 | 5 | 2 | 1 | 1 | 2 | | | 39 | 40 | *11.4* | *15.9* |
| 11.0 | 7 | | 5 | 1 | 4 | | 1 | | 6 | 2 | 3 | | | | 4 | | 8 | | 5 | 2 | 3 | | 1 | | 47 | 5 | *13.8* | *2.0* |
| .5 | 5 | | 2 | | | | 1 | | 5 | 1 | 2 | | | | 2 | | 3 | | 2 | | 3 | | | | 25 | 1 | *7.3* | *0.4* |
| 12.0 | 5 | | | | | | 3 | | 1 | | 1 | | 3 | | 1 | | 5 | | 5 | | 3 | | | | 27 | | *7.9* | |
| .5 | 5 | | | | 1 | | 2 | | 4 | | 2 | | 3 | | | | 3 | | 2 | | 1 | | | | 23 | | *6.7* | |
| 13.0 | 3 | | | | | | 2 | | 4 | | | | 3 | | | | 3 | | 1 | | 1 | | | | 17 | | *5.0* | |
| .5 | 2 | | 1 | | 1 | | 2 | | 2 | | 1 | | 2 | | | | 1 | | 5 | | | | | | 17 | | *5.0* | |
| 14.0 | 1 | | 1 | | | | | | | | 2 | | | | 1 | | 2 | | 2 | | | | | | 9 | | *2.6* | |
| .5 | | | | | 2 | | | | 1 | | 3 | | 1 | | | | 2 | | 1 | | 3 | | | | 13 | | *3.8* | |
| 15.0 | | | 2 | | | | | | | | 5 | | 1 | | 2 | | 2 | | | | 2 | | | | 14 | | *4.1* | |
| .5 | 1 | | | | | | | | | | 9 | | 1 | | 1 | | 1 | | 3 | | 2 | | | | 18 | | *5.3* | |
| 16.0 | 1 | | | | | | | | 1 | | 4 | | | | 1 | | 2 | | 3 | | 3 | | | | 15 | | *4.4* | |
| .5 | | | 1 | | | | | | | | 3 | | 2 | | 2 | | | | | | | | | | 8 | | *2.3* | |
| 17.0 | | | | | | | | | | | | | 1 | | | | | | | | | | | | 1 | | *0.3* | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 39 | 19 | 25 | 46 | 31 | 39 | 25 | 21 | 33 | 37 | 39 | 13 | 18 | 6 | 23 | 18 | 41 | 17 | 34 | 16 | 32 | 19 | 1 | 0 | 341 | 251 | *99.9* | *100.0* |

Table $A_3$. *Paita 1961.*

| Length m. | Jan ♂♂ | Jan ♀♀ | Feb ♂♂ | Feb ♀♀ | Mar ♂♂ | Mar ♀♀ | Apr ♂♂ | Apr ♀♀ | May ♂♂ | May ♀♀ | Jun ♂♂ | Jun ♀♀ | Jul ♂♂ | Jul ♀♀ | Aug ♂♂ | Aug ♀♀ | Sep ♂♂ | Sep ♀♀ | Oct ♂♂ | Oct ♀♀ | Nov ♂♂ | Nov ♀♀ | Dec ♂♂ | Dec ♀♀ | Total ♂♂ | Total ♀♀ | Percent ♂♂ | Percent ♀♀ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | 1 | | | | | | | | | 1 | | | | | | 1 | 1 | *0.3* | *0.4* |
| 8.0 | | | | 1 | | 2 | 1 | 1 | | | | 1 | | | | | 1 | | | | | 1 | | | 2 | 6 | *0.7* | *2.1* |
| .5 | | | | 2 | | 1 | 3 | 4 | | 4 | 2 | 6 | 1 | | | 1 | 1 | | | | | | | 1 | 7 | 19 | *2.5* | *6.7* |
| 9.0 | | 1 | 1 | 3 | 2 | 1 | 1 | 6 | 1 | 4 | 2 | 5 | | 1 | | 1 | | 3 | | 4 | | 2 | | 2 | 7 | 33 | *2.5* | *11.7* |
| .5 | 1 | 3 | 2 | 7 | 5 | 7 | 4 | 10 | 9 | 15 | 8 | 19 | 1 | 4 | 5 | 4 | 2 | 7 | | 9 | | 4 | 1 | 5 | 38 | 94 | *13.4* | *33.2* |
| 10.0 | 2 | 4 | 8 | 6 | 2 | 8 | 4 | 10 | 5 | 8 | 4 | 19 | 1 | 9 | 2 | 7 | 2 | 5 | 2 | 7 | 1 | 4 | 2 | 2 | 35 | 89 | *12.3* | *31.4* |
| .5 | 4 | | 8 | 1 | 5 | 3 | 2 | 3 | 9 | 2 | 3 | 6 | 2 | 5 | 3 | | 1 | 4 | 5 | 1 | 3 | 2 | 4 | 2 | 49 | 29 | *17.3* | *10.2* |
| 11.0 | 2 | 1 | 10 | 1 | 2 | | 2 | | 1 | 3 | 2 | 1 | 1 | 1 | 3 | 2 | 1 | | | | 2 | 1 | 4 | | 30 | 10 | *10.6* | *3.5* |
| .5 | | | 8 | | | | | | 1 | | 1 | | | 1 | 2 | | 2 | | 1 | | 1 | 1 | 2 | | 18 | 2 | *6.3* | *0.7* |
| 12.0 | 5 | | 1 | | | | | | | | | | | | | | | | 1 | | 1 | | | | 8 | | *2.8* | |
| .5 | 3 | | | | | | | | 1 | | 1 | | | | | | | | | | | | 1 | | 6 | | *2.1* | |
| 13.0 | 1 | | 1 | | | | 3 | | 3 | | | | | | | | 1 | | | | | | 1 | | 10 | | *3.5* | |
| .5 | 1 | | 3 | | 4 | | 2 | | 1 | | | | 2 | | | | | | | | 2 | | | | 15 | | *5.3* | |
| 14.0 | 5 | | 1 | | | | | | 1 | | 1 | | | | | | | | | | 3 | | | | 11 | | *3.9* | |
| .5 | 3 | | | | 1 | | | | | | | | | | | | | | 1 | | 3 | | | | 8 | | *2.8* | |
| 15.0 | | | | | 1 | | | | | | | | 1 | | 1 | | | | | | 3 | | | | 6 | | *2.1* | |
| .5 | 3 | | 1 | | | | | | | | | | 3 | | 2 | | 2 | | | | 9 | | 1 | | 21 | | *7.4* | |
| 16.0 | | | | | | | | | 1 | | | | 1 | | 3 | | 2 | | | | 2 | | | | 9 | | *3.2* | |
| .5 | | | | | | | | | | | | | 2 | | | | 1 | | | | | | | | 3 | | *1.0* | |
| 17.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 30 | 9 | 44 | 21 | 22 | 22 | 22 | 34 | 33 | 37 | 24 | 57 | 15 | 21 | 21 | 15 | 16 | 19 | 11 | 21 | 30 | 15 | 16 | 12 | 284 | 283 | *100.0* | *99.9* |

Table $A_4$. *Paita 1959—61.*

| Length | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | | Total | | Percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| m. | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | 1 | | | | | | | | | | 1 | | | | | | 1 | 1 | *0.1* | *0.1* |
| 8.0 | | | | 3 | 2 | 2 | 1 | 2 | | | 1 | | | | | 1 | 1 | | | | 1 | 3 | | | 5 | 12 | *0.6* | *1.8* |
| .5 | | 1 | | 3 | 3 | 2 | 3 | 4 | | 4 | 2 | 6 | 1 | | 1 | 2 | 1 | 3 | | 2 | 1 | 4 | | 2 | 12 | 33 | *1.4* | *4.8* |
| 9.0 | | 7 | 2 | 8 | 2 | 10 | 2 | 9 | 1 | 9 | 3 | 7 | | 2 | | 3 | 3 | 9 | 2 | 8 | 1 | 5 | 1 | 5 | 17 | 82 | *2.0* | *12.0* |
| .5 | 3 | 9 | 2 | 22 | 8 | 20 | 6 | 14 | 10 | 25 | 12 | 25 | 3 | 5 | 6 | 14 | 6 | 24 | 3 | 25 | 2 | 14 | 4 | 14 | 65 | 211 | *7.6* | *30.8* |
| 10.0 | 7 | 10 | 13 | 20 | 12 | 18 | 11 | 16 | 5 | 23 | 6 | 29 | 5 | 16 | 4 | 18 | 3 | 13 | 4 | 23 | 17 | 22 | 7 | 13 | 94 | 221 | *11.0* | *32.3* |
| .5 | 6 | | 15 | 9 | 10 | 9 | 6 | 10 | 17 | 6 | 4 | 10 | 4 | 10 | 11 | 5 | 11 | 17 | 12 | 10 | 9 | 10 | 10 | 3 | 115 | 99 | *13.5* | *14.5* |
| 11.0 | 9 | 1 | 15 | 2 | 6 | | 3 | | 7 | 5 | 5 | 3 | 5 | 1 | 8 | 3 | 11 | 2 | 8 | 3 | 11 | 1 | 9 | 1 | 97 | 22 | *11.3* | *3.2* |
| .5 | 5 | | 10 | | | | 1 | | 6 | 1 | 6 | 1 | 1 | 1 | 6 | | 8 | | 8 | | 6 | 1 | 2 | | 59 | 4 | *6.9* | *0.6* |
| 12.0 | 10 | | 1 | | | | 3 | | 1 | | 1 | | 3 | | 4 | | 7 | | 8 | | 8 | | | | 46 | | *5.4* | |
| .5 | 8 | | | | 1 | | 2 | | 5 | | 8 | | 3 | | 3 | | 6 | | 3 | | 2 | | 1 | | 42 | | *4.9* | |
| 13.0 | 4 | | 1 | | | | 5 | | 7 | | 3 | | 3 | | 6 | | 7 | | 3 | | 3 | | 2 | | 44 | | *5.1* | |
| .5 | 3 | | 4 | | 5 | | 4 | | 3 | | 3 | | 5 | | 5 | | 2 | | 5 | | 5 | | 2 | | 46 | | *5.4* | |
| 14.0 | 6 | | 2 | | | | | | 1 | | 4 | | 2 | | 1 | | 3 | | 2 | | 6 | | | | 27 | | *3.2* | |
| .5 | 3 | | | | 3 | | | | 1 | | 5 | | 2 | | 4 | | 3 | | 3 | | 10 | | | | 34 | | *4.0* | |
| 15.0 | | | 2 | | 1 | | | | | | 5 | | 4 | | 6 | | 4 | | 2 | | 7 | | 2 | | 33 | | *3.9* | |
| .5 | 4 | | 1 | | | | | | | | 10 | | 6 | | 7 | | 4 | | 5 | | 15 | | 3 | | 55 | | *6.4* | |
| 16.0 | 1 | | | | | | | | 2 | | 6 | | 3 | | 6 | | 5 | | 5 | | 12 | | 1 | | 41 | | *4.8* | |
| .5 | | | 1 | | | | | | | | 3 | | 5 | | 4 | | 1 | | 3 | | | | | | 17 | | *2.0* | |
| 17.0 | | | | | | | | | | | 2 | | 1 | | | | | | | | | | 1 | | 4 | | *0.5* | |
| .5 | | | | | | | | | | | | | | | | | 1 | | | | | | | | 1 | | *0.1* | |
| | 69 | 28 | 69 | 67 | 53 | 61 | 47 | 55 | 66 | 74 | 88 | 82 | 56 | 35 | 82 | 46 | 87 | 68 | 77 | 71 | 116 | 60 | 45 | 38 | 855 | 685 | *100.1* | *100.1* |

Table $B_1$. *Pisco 1960.*

| Length m. | Jan ♂♂ | ♀♀ | Feb ♂♂ | ♀♀ | Mar ♂♂ | ♀♀ | Apr ♂♂ | ♀♀ | May ♂♂ | ♀♀ | Jun ♂♂ | ♀♀ | Jul ♂♂ | ♀♀ | Aug ♂♂ | ♀♀ | Sep ♂♂ | ♀♀ | Oct ♂♂ | ♀♀ | Nov ♂♂ | ♀♀ | Dec ♂♂ | ♀♀ | Total ♂♂ | ♀♀ | Percent ♂♂ | ♀♀ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | 1 | | | | 3 | | | | 1 | 3 | *1* | *5* |
| 8.0 | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | | 3 | 2 | *3* | *3* |
| .5 | | | | | | | | | | | | | | | 1 | | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 5 | 7 | *6* | *12* |
| 9.0 | | | | | | | | | | | | | | | | | | 5 | | | 1 | 6 | 1 | | 2 | 11 | *2* | *19* |
| .5 | | | | | | | | | | | | | | | | | | 3 | 1 | 3 | 1 | 4 | 1 | 2 | 3 | 12 | *3* | *21* |
| 10.0 | | | | | | | | | | | | | | | 3 | 2 | 5 | 2 | 1 | 5 | 2 | 7 | 1 | 3 | 12 | 19 | *13* | *33* |
| .5 | | | | | | | | | | | | | | | | | 2 | | | 1 | 4 | 1 | | 1 | 6 | 3 | *7* | *5* |
| 11.0 | | | | | | | | | | | | | | | | | | | | | 5 | | 1 | 1 | 6 | 1 | *7* | *2* |
| .5 | | | | | | | | | | | | | | | | | 3 | | 2 | | 1 | | 2 | | 8 | | *9* | |
| 12.0 | | | | | | | | | | | | | | | | | | | 2 | | | | 4 | | 6 | | *7* | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | 5 | | 5 | | *6* | |
| 13.0 | | | | | | | | | | | | | | | 1 | | | | 3 | | 2 | | 1 | | 7 | | *8* | |
| .5 | | | | | | | | | | | | | | | 1 | | 1 | | 5 | | 2 | | | | 9 | | *10* | |
| 14.0 | | | | | | | | | | | | | | | 1 | | | | 3 | | | | | | 4 | | *4* | |
| .5 | | | | | | | | | | | | | | | | | | | 4 | | 3 | | | | 7 | | *8* | |
| 15.0 | | | | | | | | | | | | | | | | | | | 1 | | 1 | | 1 | | 3 | | *3* | |
| .5 | | | | | | | | | | | | | | | | | | | 2 | | 1 | | | | 3 | | *3* | |
| 16.0 | | | | | | | | | | | | | | | | | | | | | 1 | | | | 1 | | *1* | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | 7 | 2 | 13 | 12 | 26 | 11 | 26 | 25 | 19 | 8 | 91 | 58 | *101* | *100* |

Table $B_2$. *Pisco 1961.*

| Length | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | | Total | | Percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| m. | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| 6.5 | | | | | | | | | | | | | | | 1 | | | | | | | 1 | | | 1 | 1 | *0.5* | *0.8* |
| 7.0 | | | | | | | | | | | 1 | | | | 2 | | | | | | | | | | 3 | | *1.6* | |
| .5 | | | | | | | | | | | | 1 | | 2 | | 1 | | | | | | 1 | 2 | 1 | 2 | 6 | *1.0* | *4.6* |
| 8.0 | | | | | | | | | | | | | | | | | | 1 | | | | | | 3 | | 4 | | *3.1* |
| .5 | | | | | | 1 | 1 | 2 | | | | | | 1 | 2 | 1 | | | 1 | | | | | | 4 | 5 | *2.1* | *3.8* |
| 9.0 | 1 | 4 | | | | 1 | 2 | 2 | | 5 | 3 | 5 | 1 | 1 | | 3 | | | | 3 | 1 | 3 | | 1 | 8 | 28 | *4.1* | *21.4* |
| .5 | 1 | 2 | | | | 3 | | 1 | 2 | 3 | | 4 | | 4 | | 5 | 1 | 2 | 1 | 1 | | 1 | | 5 | 5 | 31 | *2.6* | *23.7* |
| 10.0 | 1 | 4 | | 1 | 1 | | | 10 | 3 | 4 | | 2 | | 2 | 2 | | 3 | 2 | | 1 | 3 | 6 | 2 | 2 | 15 | 34 | *7.8* | *26.0* |
| .5 | | | | 1 | 1 | | 5 | 1 | 2 | 1 | 5 | 1 | 2 | 1 | 1 | 1 | | 3 | | | 2 | 6 | 2 | | 20 | 15 | *10.4* | *11.5* |
| 11.0 | 1 | 1 | 1 | | 1 | | 3 | | 5 | 2 | 2 | 1 | 2 | 1 | 2 | | 1 | | 2 | | 4 | | 2 | | 26 | 5 | *13.5* | *3.8* |
| .5 | 2 | | | | | | 2 | | 2 | | | | 1 | 1 | 3 | | 1 | | | | | 1 | 2 | | 13 | 2 | *6.7* | *1.5* |
| 12.0 | 5 | | | | | | 2 | | 1 | | 1 | | 1 | | | | | | | | | | | | 10 | | *5.2* | |
| .5 | 1 | | | | | | 1 | | 3 | | 1 | | | | 2 | | | | 1 | | | | | | 9 | | *4.7* | |
| 13.0 | 2 | | | | 1 | | | | 3 | | 1 | | 2 | | | | | | 4 | | 1 | | 1 | | 15 | | *7.8* | |
| .5 | 1 | | 3 | | | | | | 3 | | | | 3 | | 2 | | | | 4 | | 1 | | 1 | | 18 | | *9.3* | |
| 14.0 | 2 | | 3 | | | | | | 8 | | | | 2 | | 1 | | | | 1 | | 1 | | | | 18 | | *9.3* | |
| .5 | 3 | | 1 | | | | | | | | | | | | | | 1 | | 1 | | 1 | | | | 7 | | *3.6* | |
| 15.0 | 1 | | | | | | | | 1 | | | | | | | | 1 | | 1 | | | | | | 4 | | *2.1* | |
| .5 | 1 | | 1 | | | | 1 | | | | | | 1 | | | | | | 2 | | 1 | | 2 | | 9 | | *4.7* | |
| 16.0 | | | | | | | 1 | | | | | | | | 1 | | | | | | | | 1 | | 3 | | *1.6* | |
| .5 | 1 | | | | | | | | | | | | | | | | | | | | | | | | 1 | | *0.5* | |
| 17.0 | 1 | | | | | | | | | | | | | | | | | | 1 | | | | | | 2 | | *1.0* | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 24 | 11 | 9 | 2 | 4 | 5 | 18 | 16 | 33 | 15 | 14 | 14 | 15 | 13 | 19 | 11 | 8 | 8 | 19 | 5 | 15 | 19 | 15 | 12 | 193 | 131 | *100.1* | *100.2* |

Table $B_8$. *Pisco 1960—61.*

| Length | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | | Total | | Percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| m. | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| 6.5 | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | 1 | | | | 2 | | | | | | 1 | | | | 1 | 1 | *0.4* | *0.5* |
| .5 | | | | | | | | | | | | 1 | | 2 | | 1 | 1 | | | | | | | | 3 | | *1.1* | |
| 8.0 | | | | | | | | | | | | | | | | | | 1 | | | 4 | | 2 | 1 | 3 | 9 | *1.1* | *4.8* |
| .5 | | | | | | 1 | 1 | 2 | | | | | | 1 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 6 | *1.1* | *3.2* |
| 9.0 | 1 | 4 | | | | 1 | 2 | 2 | | 5 | 3 | 5 | 1 | 1 | | 3 | 1 | 5 | 2 | 3 | 2 | 9 | 1 | 1 | 10 | 39 | *3.5* | *20.6* |
| .5 | 1 | 2 | | | | 3 | | 1 | 2 | 3 | | 4 | | 4 | | 5 | 1 | 5 | 2 | 4 | 1 | 5 | 1 | 7 | 8 | 43 | *2.8* | *22.8* |
| 10.0 | 1 | 4 | | 1 | 1 | | | 10 | 3 | 4 | | 2 | | 2 | 5 | 2 | 8 | 4 | 1 | 6 | 5 | 13 | 3 | 5 | 27 | 53 | *9.5* | *28.0* |
| .5 | | | | 1 | 1 | | 5 | 1 | 2 | 1 | 5 | 1 | 2 | 1 | 1 | 1 | 2 | 3 | | 1 | 6 | 7 | 2 | 1 | 26 | 18 | *9.2* | *9.5* |
| 11.0 | 1 | 1 | 1 | | 1 | | 3 | | 5 | 2 | 2 | 1 | 2 | 1 | 2 | | 1 | | 2 | | 9 | | 3 | 1 | 32 | 6 | *11.3* | *3.2* |
| .5 | 2 | | | | | | 2 | | 2 | | | | 1 | 1 | 3 | | 4 | | 2 | | 1 | 1 | 4 | | 21 | 2 | *7.4* | *1.1* |
| 12.0 | 5 | | | | | | 2 | | 1 | | 1 | | 1 | | | | | | 2 | | | | 4 | | 16 | | *5.6* | |
| .5 | 1 | | | | | | 1 | | 3 | | 1 | | | | 2 | | | | 1 | | | | 5 | | 14 | | *4.9* | |
| 13.0 | 2 | | | | 1 | | | | 3 | | 1 | | 2 | | 1 | | | | 7 | | 3 | | 2 | | 22 | | *7.8* | |
| .5 | 1 | | 3 | | | | | | 3 | | | | 3 | | 3 | | 1 | | 9 | | 3 | | 1 | | 27 | | *9.5* | |
| 14.0 | 2 | | 3 | | | | | | 8 | | | | 2 | | 2 | | | | 4 | | 1 | | | | 22 | | *7.8* | |
| .5 | 3 | | 1 | | | | | | | | | | | | | | 1 | | 5 | | 4 | | | | 14 | | *4.9* | |
| 15.0 | 1 | | | | | | | | 1 | | | | | | | | 1 | | 2 | | 1 | | 1 | | 7 | | *2.5* | |
| .5 | 1 | | 1 | | | | 1 | | | | | | 1 | | | | | | 4 | | 2 | | 2 | | 12 | | *4.2* | |
| 16.0 | | | | | | | 1 | | | | | | | | 1 | | | | | | 1 | | 1 | | 4 | | *1.4* | |
| .5 | 1 | | | | | | | | | | | | | | | | | | | | | | | | 1 | | *0.4* | |
| 17.0 | 1 | | | | | | | | | | | | | | | | | | 1 | | | | | | 2 | | *0.7* | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 24 | 11 | 9 | 2 | 4 | 5 | 18 | 16 | 33 | 15 | 14 | 14 | 15 | 13 | 26 | 13 | 21 | 20 | 45 | 16 | 41 | 44 | 34 | 20 | 284 | 189 | *100.3* | *100.1* |

Table C. *Iquique 1960.*

| Length | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | | Total | | Percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| m. | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | *0.8* | *1* |
| 8.0 | | | | | | | 1 | 1 | | 1 | 1 | | | | | | | | | | 1 | | 1 | 1 | 4 | 3 | *3.2* | *4* |
| .5 | | | | | | | | 1 | 1 | 1 | | 2 | | | | | | | 1 | | 2 | 1 | 2 | 2 | 6 | 7 | *4.8* | *8* |
| 9.0 | | | | | | | | 1 | 1 | 1 | | 4 | | | | 1 | 1 | | 2 | 2 | 3 | 3 | | 2 | 7 | 14 | *5.6* | *17* |
| .5 | | | | | 1 | | | 2 | 1 | 2 | | 2 | | | 1 | | | 2 | | 3 | 2 | 2 | | 3 | 4 | 17 | *3.2* | *20* |
| 10.0 | | | | | | | 1 | 1 | 1 | 5 | 4 | 2 | | | 2 | 1 | 2 | 3 | | 3 | 1 | 3 | 1 | 3 | 12 | 21 | *9.7* | *25* |
| .5 | | | | | | | 1 | 1 | 1 | 1 | 2 | | | | | 2 | | 2 | 1 | 2 | 2 | 5 | | 1 | 7 | 14 | *5.6* | *17* |
| 11.0 | | | | | 1 | | | | 1 | | | | | | | 2 | 2 | | 2 | 1 | 8 | 1 | 2 | | 15 | 5 | *12.1* | *6* |
| .5 | | | | | 1 | | 1 | | | | | | | | 2 | 1 | 2 | | 2 | | 4 | | 3 | | 14 | 2 | *11.3* | *2* |
| 12.0 | | | | | | | | | | | 1 | | | | 1 | | | | 3 | | 1 | | 1 | | 7 | | *5.6* | |
| .5 | | | | | | | | | | | | | | | 1 | | | | 1 | | 1 | | | | 3 | | *2.4* | |
| 13.0 | | | | | | | | | | | | | | | 8 | | 1 | | | | 2 | | | | 11 | | *8.9* | |
| .5 | | | | | | | | | | | 1 | | | | | | 5 | | 1 | | 1 | | | | 8 | | *6.5* | |
| 14.0 | | | | | | | | | | | | | | | | | 5 | | 3 | | 2 | | | | 10 | | *8.1* | |
| .5 | | | | | | | 1 | | | | | | | | | | 1 | | 1 | | | | | | 3 | | *2.4* | |
| 15.0 | | | | | | | | | | | | | | | 1 | | | | 1 | | 1 | | | | 3 | | *2.4* | |
| .5 | | | | | | | | | 1 | | | | | | 1 | | 3 | | 1 | | | | | | 6 | | *4.8* | |
| 16.0 | | | | | | | | | | | | | | | | | | | 1 | | 1 | | | | 2 | | *1.6* | |
| .5 | | | | | | | | | | | | | | | 1 | | | | | | | | | | 1 | | *0.8* | |
| 17.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | 3 | | 5 | 7 | 7 | 11 | 9 | 10 | | | 18 | 7 | 22 | 7 | 20 | 11 | 32 | 15 | 11 | 13 | 124 | 84 | *99.8* | *100* |

Table D. *Talcahuano 1961.*

| Length | Jan | | Feb | | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | | Dec | | Total | | Percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| m. | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ | ♂♂ | ♀♀ |
| 6.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 3 | *6* | *23* |
| .5 | | | | | | | 2 | 3 | | | | | | | | | | | | | | | | | 1 | 2 | *3* | *15* |
| 9.0 | | | | | | | 1 | 2 | | | | | | | | | | | | | | | | | 2 | 2 | *6* | *15* |
| .5 | | | | | | 1 | 2 | 1 | | | | | | | | | | | | | | | | | 2 | 3 | *6* | *23* |
| 10.0 | | | | | 1 | 2 | 1 | 1 | | | | | | | | | | | | | | | | | 4 | 2 | *13* | *15* |
| .5 | | | | | 1 | | 3 | 2 | | | | | | | | | | | | | | | | | 2 | | *6* | |
| 11.0 | | | | | 1 | | 1 | | | | | | | | | | | | | | | | | | 2 | 1 | *6* | *8* |
| .5 | | | | | | | 2 | 1 | | | | | | | | | | | | | | | | | 4 | | *13* | |
| 12.0 | | | | | 2 | | | | 2 | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | 2 | | *6* | |
| 13.0 | | | | | | | | | 2 | | | | | | | | | | | | | | | | 2 | | *6* | |
| .5 | | | | | | | | | 1 | | 1 | | | | | | | | | | | | | | 2 | | *6* | |
| 14.0 | | | | | | | | | 1 | | 1 | | | | | | | | | | | | | | 2 | | *6* | |
| .5 | | | | | 1 | | | | 1 | | | | | | | | | | | | | | | | 3 | | *9* | |
| 15.0 | | | | | | | | | | | 3 | | | | | | | | | | | | | | 1 | | *3* | |
| .5 | | | | | | | | | | | 1 | | | | | | | | | | | | | | 1 | | *3* | |
| 16.0 | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| .5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | 6 | 3 | 12 | 10 | 8 | | 6 | | | | | | | | | | | | | | 32 | 13 | *98* | *99* |

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